S. I. A.

REPORT

OF THE

FORTY-FOURTH MEETING

OF THE

BRITISH ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE;

HELD AT

BELFAST IN AUGUST 1874.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
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ALERE FLAMMAM.

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OBJECTS.

The Association contemplates no interference with the ground occupied by other institutions. Its objects are:—To give a stronger impulse and a more systematic direction to scientific inquiry,—to promote the intercourse of those who cultivate Science in different parts of the British Empire, with one another and with foreign philosophers,—to obtain a more general attention to the objects of Science, and a removal of any disadvantages of a public kind which impede its progress.

RULES.

Admission of Members and Associates.

All persons who have attended the first Meeting shall be entitled to become Members of the Association, upon subscribing an obligation to conform to its Rules.

The Fellows and Members of Chartered Literary and Philosophical Societies publishing Transactions, in the British Empire, shall be entitled, in like manner, to become Members of the Association.

The Officers and Members of the Councils, or Managing Committees, of Philosophical Institutions shall be entitled, in like manner, to become Members of the Association.

All Members of a Philosophical Institution recommended by its Council or Managing Committee shall be entitled, in like manner, to become Members of the Association.

Persons not belonging to such Institutions shall be elected by the General Committee or Council, to become Life Members of the Association, Annual Subscribers, or Associates for the year, subject to the approval of a General Meeting.

Compositions, Subscriptions, and Privileges.

Life Members shall pay, on admission, the sum of Ten Pounds. They shall receive *gratuitously* the Reports of the Association which may be pub-

lished after the date of such payment. They are eligible to all the offices of the Association.

Annual Subscribers shall pay, on admission, the sum of Two Pounds, and in each following year the sum of One Pound. They shall receive *gratuitously* the Reports of the Association for the year of their admission and for the years in which they continue to pay *without intermission* their Annual Subscription. By omitting to pay this Subscription in any particular year, Members of this class (Annual Subscribers) *lose for that and all future years* the privilege of receiving the volumes of the Association *gratis*: but they may resume their Membership and other privileges at any subsequent Meeting of the Association, paying on each such occasion the sum of One Pound. They are eligible to all the Offices of the Association.

Associates for the year shall pay on admission the sum of One Pound. They shall not receive *gratuitously* the Reports of the Association, nor be eligible to serve on Committees, or to hold any office.

The Association consists of the following classes:—

1. Life Members admitted from 1831 to 1845 inclusive, who have paid on admission Five Pounds as a composition.
2. Life Members who in 1846, or in subsequent years, have paid on admission Ten Pounds as a composition.
3. Annual Members admitted from 1831 to 1839 inclusive, subject to the payment of One Pound annually. [May resume their Membership after intermission of Annual Payment.]
4. Annual Members admitted in any year since 1839, subject to the payment of Two Pounds for the first year, and One Pound in each following year. [May resume their Membership after intermission of Annual Payment.]
5. Associates for the year, subject to the payment of One Pound.
6. Corresponding Members nominated by the Council.

And the Members and Associates will be entitled to receive the annual volume of Reports, *gratis*, or to *purchase* it at reduced (or Members') price, according to the following specification, viz.:—

1. *Gratis.*—Old Life Members who have paid Five Pounds as a composition for Annual Payments, and previous to 1845 a further sum of Two Pounds as a Book Subscription, or, since 1845, a further sum of Five Pounds.

   New Life Members who have paid Ten Pounds as a composition.

   Annual Members who have not intermitted their Annual Subscription.

2. *At reduced or Members' Prices,* viz. two thirds of the Publication Price.—Old Life Members who have paid Five Pounds as a composition for Annual Payments, but no further sum as a Book Subscription.

   Annual Members who have intermitted their Annual Subscription.

   Associates for the year. [Privilege confined to the volume for that year only.]

3. Members may purchase (for the purpose of completing their sets) any of the first seventeen volumes of Transactions of the Association, *and of which more than* 100 *copies remain,* at one third of the Publication Price. Application to be made at the Office of the Association, 22 Albemarle Street, London, W.

Volumes not claimed within two years of the date of publication can only be issued by direction of the Council.

Subscriptions shall be received by the Treasurer or Secretaries.

Meetings.

The Association shall meet annually, for one week, or longer. The place of each Meeting shall be appointed by the General Committee two years in advance; and the Arrangements for it shall be entrusted to the Officers of the Association.

General Committee.

The General Committee shall sit during the week of the Meeting, or longer, to transact the business of the Association. It shall consist of the following persons:—

CLASS A. PERMANENT MEMBERS.

1. Members of the Council, Presidents of the Association, and Presidents of Sections for the present and preceding years, with Authors of Reports in the Transactions of the Association.

2. Members who by the publication of Works or Papers have furthered the advancement of those subjects which are taken into consideration at the Sectional Meetings of the Association. *With a view of submitting new claims under this Rule to the decision of the Council, they must be sent to the Assistant General Secretary at least one month before the Meeting of the Association. The decision of the Council on the claims of any Member of the Association to be placed on the list of the General Committee to be final.*

CLASS B. TEMPORARY MEMBERS.

1. The President for the time being of any Scientific Society publishing Transactions or, in his absence, a delegate representing him. *Claims under this Rule to be sent to the Assistant General Secretary before the opening of the Meeting.*

2. Office-bearers for the time being, or delegates, altogether not exceeding three, from Scientific Institutions established in the place of Meeting. *Claims under this Rule to be approved by the Local Secretaries before the opening of the Meeting.*

3. Foreigners and other individuals whose assistance is desired, and who are specially nominated in writing, for the Meeting of the year, by the President and General Secretaries.

4. Vice-Presidents and Secretaries of Sections.

Organizing Sectional Committees.*

The Presidents, Vice-Presidents, and Secretaries of the several Sections are nominated by the Council, and have power to act until their names are submitted to the General Committee for election.

From the time of their nomination they constitute Organizing Committees for the purpose of obtaining information upon the Memoirs and Reports likely to be submitted to the Sections†, and of preparing Reports thereon,

* Passed by the General Committee, Edinburgh, 1871.

† *Notice to Contributors of Memoirs.*—Authors are reminded that, under an arrangement dating from 1871, the acceptance of Memoirs, and the days on which they are to be

and on the order in which it is desirable that they should be read, to be presented to the Committees of the Sections at their first Meeting.

An Organizing Committee may also hold such preliminary Meetings as the President of the Committee thinks expedient, but shall, under any circumstances, meet on the first Wednesday of the Annual Meeting, at 11 A.M., to settle the terms of their Report, after which their functions as an Organizing Committee shall cease.

Constitution of the Sectional Committees.*

On the first day of the Annual Meeting, the President, Vice-Presidents, and Secretaries of each Section having been appointed by the General Committee, these Officers, and those previous Presidents and Vice-Presidents of the Section who may desire to attend, are to meet, at 2 P.M., in their Committee Rooms, and enlarge the Sectional Committees by selecting individuals from among the Members (not Associates) present at the Meeting whose assistance they may particularly desire. The Sectional Committees thus constituted shall have power to add to their number from day to day.

The List thus formed is to be entered daily in the Sectional Minute-Book, and a copy forwarded without delay to the Printer, who is charged with publishing the same before 8 A.M. on the next day, in the Journal of the Sectional Proceedings.

Business of the Sectional Committees.

Committee Meetings are to be held on the Wednesday at 2 P.M., on the following Thursday, Friday, Saturday, Monday, and Tuesday, from 10 to 11 A.M., punctually, for the objects stated in the Rules of the Association, and specified below.

The business is to be conducted in the following manner:—

At the first meeting, one of the Secretaries will read the Minutes of last year's proceedings, as recorded in the Minute-Book, and the Synopsis of Recommendations adopted at the last Meeting of the Association and printed in the last volume of the Transactions. He will next proceed to read the Report of the Organizing Committee †. The List of Communications to be read on Thursday shall be then arranged, and the general distribution of business throughout the week shall be provisionally appointed. At the close of the Committee Meeting the Secretaries shall forward to the Printer a List of the Papers appointed to be read. The Printer is charged with publishing the same before 8 A.M. on Thursday in the Journal.

On the second day of the Annual Meeting, and the following days, the

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read, are now as far as possible determined by Organizing Committees for the several Sections *before the beginning of the Meeting*. It has therefore become necessary, in order to give an opportunity to the Committees of doing justice to the several Communications, that each Author should prepare an Abstract of his Memoir, of a length suitable for insertion in the published Transactions of the Association, and that he should send it, together with the original Memoir, by book-post, on or before ...., addressed thus—"General Secretaries, British Association, 22 Albemarle Street, London, W. For Section ...." If it should be inconvenient to the Author that his Paper should be read on any particular days, he is requested to send information thereof to the Secretaries in a separate note.

* Passed by the General Committee, Edinburgh, 1871.

† This and the following sentence were added by the General Committee, 1871.

Secretaries are to correct, on a copy of the Journal, the list of papers which have been read on that day, to add to it a list of those appointed to be read on the next day, and to send this copy of the Journal as early in the day as possible to the Printers, who are charged with printing the same before 8 A.M. next morning in the Journal. It is necessary that one of the Secretaries of each Section should call at the Printing Office and revise the proof each evening.

Minutes of the proceedings of every Committee are to be entered daily in the Minute-Book, which should be confirmed at the next meeting of the Committee.

Lists of the Reports and Memoirs read in the Sections are to be entered in the Minute-Book daily, which, with *all Memoirs and Copies or Abstracts of Memoirs furnished by Authors, are to be forwarded, at the close of the Sectional Meetings,* to the Assistant General Secretary.

The Vice-Presidents and Secretaries of Sections become *ex officio* temporary Members of the General Committee (*vide* p. xix), and will receive, on application to the Treasurer in the Reception Room, Tickets entitling them to attend its Meetings.

The Committees will take into consideration any suggestions which may be offered by their Members for the advancement of Science. They are specially requested to review the recommendations adopted at preceding Meetings, as published in the volumes of the Association and the communications made to the Sections at this Meeting, for the purposes of selecting definite points of research to which individual or combined exertion may be usefully directed, and branches of knowledge on the state and progress of which Reports are wanted; to name individuals or Committees for the execution of such Reports or researches; and to state whether, and to what degree, these objects may be usefully advanced by the appropriation of the funds of the Association, by application to Government, Philosophical Institutions, or Local Authorities.

In case of appointment of Committees for special objects of Science, it is expedient that *all Members of the Committee should be named, and one of them appointed to act as Secretary, for insuring attention to business.*

Committees have power to add to their number persons whose assistance they may require.

The recommendations adopted by the Committees of Sections are to be registered in the Forms furnished to their Secretaries, and one Copy of each is to be forwarded, without delay, to the Assistant General Secretary for presentation to the Committee of Recommendations. *Unless this be done, the Recommendations cannot receive the sanction of the Association.*

N.B.—Recommendations which may originate in any one of the Sections must *first be sanctioned by the Committee of that Section* before they can be referred to the Committee of Recommendations or confirmed by the General Committee.

Notices Regarding Grants of Money.

Committees and individuals, to whom grants of money have been entrusted by the Association for the prosecution of particular researches in Science, are required to present to each following Meeting of the Association a Report of the progress which has been made; and the Individual or the Member first named of a Committee to whom a money grant has been made must (previously to the next meeting of the Association) forward to the General

Secretaries or Treasurer a statement of the sums which have been expended, and the balance which remains disposable on each grant.

Grants of money sanctioned at any one meeting of the Association expire *a week before* the opening of the ensuing Meeting; nor is the Treasurer authorized, after that date, to allow any claims on account of such grants, unless they be renewed in the original or a modified form by the General Committee.

No Committee shall raise money in the name or under the auspices of the British Association without special permission from the General Committee to do so; and no money so raised shall be expended except in accordance with the rules of the Association.

In each Committee, the Member first named is the only person entitled to call on the Treasurer, Professor A. W. Williamson, University College, London, W.C., for such portion of the sums granted as may from time to time be required.

In grants of money to Committees, the Association does not contemplate the payment of personal expenses to the members.

In all cases where additional grants of money are made for the continuation of Researches at the cost of the Association, the sum named is deemed to include, as a part of the amount, whatever balance may remain unpaid on the former grant for the same object.

All Instruments, Papers, Drawings, and other property of the Association are to be deposited at the Office of the Association, 22 Albemarle Street, Piccadilly, London, W., when not employed in carrying on scientific inquiries for the Association.

Business of the Sections.

The Meeting Room of each Section is opened for conversation from 10 to 11 daily. *The Section Rooms and approaches thereto can be used for no notices, exhibitions, or other purposes than those of the Association.*

At 11 precisely the Chair will be taken, and the reading of communications, in the order previously made public, be commenced. At 3 P.M. the Sections will close.

Sections may, by the desire of the Committees, divide themselves into Departments, as often as the number and nature of the communications delivered in may render such divisions desirable.

A Report presented to the Association, and read to the Section which originally called for it, may be read in another Section, at the request of the Officers of that Section, with the consent of the Author.

Duties of the Doorkeepers.

1.—To remain constantly at the Doors of the Rooms to which they are appointed during the whole time for which they are engaged.

2.—To require of every person desirous of entering the Rooms the exhibition of a Member's, Associate's or Lady's Ticket, or Reporter's Ticket, signed by the Treasurer, or a Special Ticket signed by the Assistant General Secretary.

3.—Persons unprovided with any of these Tickets can only be admitted to any particular Room by order of the Secretary in that Room.

No person is exempt from these Rules, except those Officers of the Association whose names are printed.

Duties of the Messengers.

To remain constantly at the Rooms to which they are appointed, during the whole time for which they are engaged, except when employed on messages by one of the Officers directing these Rooms.

Committee of Recommendations.

The General Committee shall appoint at each Meeting a Committee, which shall receive and consider the Recommendations of the Sectional Committees, and report to the General Committee the measures which they would advise to be adopted for the advancement of Science.

All Recommendations of Grants of Money, Requests for Special Researches, and Reports on Scientific Subjects shall be submitted to the Committee of Recommendations, and not taken into consideration by the General Committee unless previously recommended by the Committee of Recommendations.

Local Committees.

Local Committees shall be formed by the Officers of the Association to assist in making arrangements for the Meetings.

Local Committees shall have the power of adding to their numbers those Members of the Association whose assistance they may desire.

Officers.

A President, two or more Vice-Presidents, one or more Secretaries, and a Treasurer shall be annually appointed by the General Committee.

Council.

In the intervals of the Meetings, the affairs of the Association shall be managed by a Council appointed by the General Committee. The Council may also assemble for the despatch of business during the week of the Meeting.

Papers and Communications.

The Author of any paper or communication shall be at liberty to reserve his right of property therein.

Accounts.

The Accounts of the Association shall be audited annually, by Auditors appointed by the General Committee.

Table showing the Places and Times of Meeting of the British Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Commencement.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
The EARL FITZWILLIAM, D.C.L., F.R.S., F.G.S., &c. YORK, September 27, 1831.	Rev. W. Vernon Harcourt, M.A., F.R.S., F.G.S.	William Gray, jun., F.G.S. Professor Phillips, M.A., F.R.S., F.G.S.
The REV. W. BUCKLAND, D.D., F.R.S., F.G.S., &c. OXFORD, June 19, 1832.	Sir David Brewster, F.R.S. L. & E., &c. Rev. W. Whewell, F.R.S., Pres. Geol. Soc.	Professor Daubeny, M.D., F.R.S., &c. Rev. Professor Powell, M.A., F.R.S., &c.
The REV. ADAM SEDGWICK, M.A., V.P.R.S., V.P.G.S. CAMBRIDGE, June 25, 1833.	G. B. Airy, F.R.S., Astronomer Royal, &c. John Dalton, D.C.L., F.R.S.	Rev. Professor Henslow, M.A., F.L.S., F.G.S. Rev. W. Whewell, F.R.S.
SIR T. MACDOUGALL BRISBANE, K.C.B., D.C.L., F.R.S. L. & E. EDINBURGH, September 8, 1834.	Sir David Brewster, F.R.S., &c. Rev. T. R. Robinson, D.D.	Professor Forbes, F.R.S. L. & E., &c. Sir John Robinson, Sec. R.S.E.
The REV. PROVOST LLOYD, LL.D. DUBLIN, August 10, 1835.	Viscount Oxmantown, F.R.S., F.R.A.S. Rev. W. Whewell, F.R.S., &c.	Sir W. R. Hamilton, Astron. Royal of Ireland, &c. Rev. Professor Lloyd, F.R.S.
The MARQUIS OF LANSDOWNE, D.C.L., F.R.S., &c. BRISTOL, August 22, 1836.	The Marquis of Northampton, F.R.S. Rev. W. D. Conybeare, F.R.S. F.G.S. J. C. Prichard, M.D., F.R.S.	Professor Daubeny, M.D., F.R.S., &c. V. F. Hovenden, Esq.
The EARL OF BURLINGTON, F.R.S., F.G.S., Chancellor of the University of London. LIVERPOOL, September 11, 1837.	The Bishop of Norwich, P.L.S., F.G.S. John Dalton, D.C.L., F.R.S. Sir Philip de Grey Egerton, Bart., F.R.S., F.G.S. Rev. W. Whewell, F.R.S.	Professor Traill, M.D. Wm. Wallace Currie, Esq. Joseph N. Walker, Pres. Royal Institution, Liverpool.
The DUKE OF NORTHUMBERLAND, F.R.S., F.G.S., &c. NEWCASTLE-ON-TYNE, August 20, 1838.	The Bishop of Durham, F.R.S., F.S.A. The Rev. W. Vernon Harcourt, F.R.S., &c. Prideaux John Selby, Esq., F.R.S.E.	John Adamson, F.L.S., &c. Wm. Hutton, F.G.S. Professor Johnston, M.A., F.R.S.
The REV. W. VERNON HARCOURT, M.A., F.R.S., &c. BIRMINGHAM, August 26, 1839.	Marquis of Northampton. Earl of Dartmouth. The Rev. T. R. Robinson, D.D. John Corrie, Esq., F.R.S. Very Rev. Principal Macfarlane	George Barker, Esq., F.R.S. Peyton Blakiston, M.D. Joseph Hodgson, Esq., F.R.S. Follett Osler, Esq.
The MARQUIS OF BREADALBANE, F.R.S. GLASGOW, September 17, 1840.	Major-General Lord Greenock, F.R.S.E. Sir David Brewster, F.R.S. Sir T. M. Brisbane, Bart., F.R.S. The Earl of Mount Edgecumbe.	Andrew Liddell, Esq. Rev. J. P. Nicol, LL.D. John Strang, Esq.
The REV. PROFESSOR WHEWELL, F.R.S., &c. PLYMOUTH, July 29, 1841.	The Earl of Morley. Lord Eliot, M.P. Sir C. Lemon, Bart. Sir D. T. Acland, Bart.	W. Snow Harris, Esq., F.R.S. Col. Hamilton Smith, F.L.S. Robert Were Fox, Esq. Richard Taylor, jun., Esq.
The LORD FRANCIS EGERTON, F.G.S. MANCHESTER, June 23, 1842.	John Dalton, D.C.L., F.R.S. Hon. and Rev. W. Herbert, F.L.S., &c. Rev. A. Sedgwick, M.A., F.R.S. W. C. Henry, M.D., F.R.S. Sir Benjamin Heywood, Bart.	Peter Clare, Esq., F.R.A.S. W. Fleming, M.D. James Heywood, Esq., F.R.S.
The EARL OF ROSSE, F.R.S. CORK, August 17, 1843.	Earl of Listowel. Viscount Adare Sir W. R. Hamilton, Pres.R.I.A. Rev. T. R. Robinson, D.D.	Professor John Stevelly, M.A. Rev. Jos. Carson, F.T.C. Dublin. William Keleher, Esq. Wm. Clear, Esq.
The REV. G. PEACOCK, D.D. (Dean of Ely), F.R.S. YORK, September 26, 1844.	Earl Fitzwilliam, F.R.S. Viscount Morpeth, F.G.S. The Hon. John Stuart Wortley, M.P. Sir David Brewster, K.H., F.R.S. Michael Faraday, Esq., D.C.L., F.R.S. Rev. W. V. Harcourt, F.R.S.	William Hatfeild, Esq., F.G.S. Thomas Meynell, Esq., F.L.S. Rev. W. Scoresby, LL.D., F.R.S. William West, Esq.

SIR JOHN F. W. HERSCHEL, Bart., F.R.S., &c. CAMBRIDGE, June 19, 1845.	The Earl of Hardwicke. The Bishop of Norwich Rev. J. Graham, D.D. Rev. G. Ainslie, D.D. G. B. Airy, Esq., M.A., D.C.L., F.R.S. The Rev. Professor Sedgwick, M.A., F.R.S.	William Hopkins, Esq., M.A., F.R.S. Professor Ansted, M.A., F.R.S.
SIR RODERICK IMPEY MURCHISON, G.C.St.S., F.R.S. SOUTHAMPTON, September 10, 1846.	The Marquis of Winchester. The Earl of Yarborough, D.C.L. Lord Ashburton, D.C.L. Viscount Palmerston, M.P. Right Hon. Charles Shaw Lefevre, M.P. Sir George T. Staunton, Bart., M.P., D.C.L., F.R.S. The Lord Bishop of Oxford, F.R.S. Professor Owen, M.D., F.R.S. Professor Powell, F.R.S.	Henry Clark, M.D. T. H. C. Moody, Esq.
SIR ROBERT HARRY INGLIS, Bart., D.C.L., F.R.S., M.P. for the University of Oxford OXFORD, June 23, 1847.	The Earl of Rosse, F.R.S. The Lord Bishop of Oxford, F.R.S. The Vice-Chancellor of the University Thomas G. Bucknall Estcourt, Esq., D.C.L., M.P. for the University of Oxford. Very Rev. the Dean of Westminster, D.D., F.R.S. Professor Daubeny, M.D., F.R.S. The Rev. Prof. Powell, M.A., F.R.S.	Rev. Robert Walker, M.A., F.R.S. H. Wentworth Acland, Esq., B.M.
The MARQUIS OF NORTHAMPTON, President of the Royal Society, &c. SWANSEA, August 9, 1848.	The Marquis of Bute, K.T. Viscount Adare, F.R.S. Sir H. T. DelaBeche, F.R.S., Pres. G.S. The Very Rev. the Dean of Llandaff, F.R.S. Lewis W. Dillwyn, Esq., F.R.S. W. R. Grove, Esq., F.R.S. J. H. Vivian, Esq., M.P., F.R.S. The Lord Bishop of St. David's	Matthew Moggridge, Esq. D. Nicol, M.D.
The REV. T. R. ROBINSON, D.D., M.R.I.A., F.R.A.S. BIRMINGHAM, September 12, 1849.	The Earl of Harrowby. The Lord Wrottesley, F.R.S. Right Hon. Sir Robert Peel, Bart., M.P., D.C.L., F.R.S. Charles Darwin, Esq., M.A., F.R.S., Sec. G.S. Professor Faraday, D.C.L., F.R.S. Sir David Brewster, K.H., LL.D., F.R.S. Rev. Prof. Willis, M.A., F.R.S.	Captain Tindal, R.N. William Wills, Esq. Bell Fletcher, Esq., M.D. James Chance, Esq.
SIR DAVID BREWSTER, K.H., LL.D., F.R.S. L. & E., Principal of the United College of St. Salvator and St. Leonard, St. Andrews EDINBURGH, July 21, 1850.	Right Hon. the Lord Provost of Edinburgh The Earl of Cathcart, K.C.B., F.R.S.E. The Earl of Rosebery, K.T., D.C.L., F.R.S. Right Hon. David Boyle (Lord Justice-General), F.R.S.E. General Sir Thomas M. Brisbane, Bart., D.C.L., F.R.S., Pres. R.S.E. Very Rev. John Lee, D.D., V.P.R.S.E., Principal of the University of Edinburgh. Professor W. P. Alison, M.D., V.P.R.S.E. Professor J. D. Forbes, F.R.S., Sec. R.S.E.	Rev. Professor Kelland, M.A., F.R.S.L. & E. Professor Balfour, M.D., F.R.S.E., F.L.S. James Tod, Esq., F.R.S.E.
GEORGE BIDDELL AIRY, Esq., D.C.L., F.R.S., Astronomer Royal IPSWICH, July 2, 1851.	The Lord Rendlesham, M.P. The Lord Bishop of Norwich Rev. Professor Sedgwick, M.A., F.R.S. Rev. Professor Henslow, M.A., F.L.S. Sir John P. Boileau, Bart., F.R.S. Sir William F. F. Middleton, Bart. J. C. Cobbold, Esq., M.P. T. B. Western, Esq.	Charles May, Esq., F.R.A.S. Dillwyn Sims, Esq. George Arthur Biddell, Esq. George Ransome, Esq., F.L.S.
COLONEL EDWARD SABINE, Royal Artillery, Treas. & V.P. of the Royal Society BELFAST, September 1, 1852.	The Earl of Enniskillen, D.C.L., F.R.S. The Earl of Rosse, M.R.I.A., Pres. R.S. Sir Henry T. DelaBeche, F.R.S. Rev. Edward Hincks, D.D., M.R.I.A. Rev. P. S. Henry, D.D., Pres. Queen's College, Belfast Rev. T. R. Robinson, D.D., Pres. R.I.A., F.R.A.S. Professor G. G. Stokes, F.R.S. Professor Stevelly, LL.D.	W. J. C. Allen, Esq. William M'Gee, M.D. Professor W. P. Wilson.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
WILLIAM HOPKINS, Esq., M.A., V.P.R.S., F.G.S., & Pres. Camb. Phil. Society. HULL, September 7, 1853.	The Earl of Carlisle, F.R.S. Lord Londesborough, F.R.S. Professor Faraday, D.C.L., F.R.S. Rev. Prof. Sedgwick, M.A., F.R.S. Charles Frost, Esq., F.S.A., Pres. of the Hull Lit. and Philos. Society. William Spence, Esq., F.R.S. Lieut.-Col. Sykes, F.R.S. Professor Wheatstone, F.R.S.	Henry Cooper, M.D., V.P. Hull. Lit. & Phil. Society. Bethel Jacobs, Esq., Pres. Hull Mechanics' Inst.
The EARL OF HARROWBY, F.R.S. LIVERPOOL, September 20, 1854.	The Lord Wrottesley, M.A., F.R.S., F.R.A.S. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. Professor Owen, M.D., LL.D., F.R.S., F.L.S., F.G.S. Rev. Professor Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., Master of Trinity College, Cambridge William Lassell, Esq., F.R.S.L. & E., F.R.A.S. Joseph Brooks Yates, F.S.A., F.R.G.S.	Joseph Dickinson, M.D., F.R.S. Thomas Inman, M.D.
The DUKE OF ARGYLL, F.R.S., F.G.S. GLASGOW, September 12, 1855.	The Very Rev. Principal Macfarlane, D.D. Sir William Jardine, Bart., F.R.S.E. Sir Charles Lyell, M.A., LL.D., F.R.S. James Smith, Esq., F.R.S. L. & E. Walter Crum, Esq., F.R.S. Thomas Graham, Esq., M.A., F.R.S., Master of the Royal Mint Professor William Thomson, M.A., F.R.S.	John Strang, LL.D. Professor Thomas Anderson, M.D. William Gourlie, Esq.
CHARLES G. B. DAUBENY, M.D., LL.D., F.R.S., Professor of Botany in the University of Oxford CHELTENHAM, August 6, 1856.	The Earl of Ducie, F.R.S., F.G.S. The Lord Bishop of Gloucester and Bristol Sir Roderick I. Murchison, G.C.St.S., D.C.L., F.R.S. Thomas Barwick Lloyd Baker, Esq. The Rev. Francis Close, M.A.	Capt. Robinson, R.A. Richard Beamish, Esq., F.R.S. John West Hugall, Esq.
The REV. HUMPHREY LLOYD, D.D., D.C.L., F.R.S. L. & E., V.P.R.I.A. DUBLIN, August 26, 1857.	The Right Honourable the Lord Mayor of Dublin The Provost of Trinity College, Dublin The Marquis of Kildare. Lord Talbot de Malahide The Lord Chancellor of Ireland The Lord Chief Baron, Dublin Sir William R. Hamilton, LL.D., F.R.A.S., Astronomer Royal of Ireland Lieut.-Colonel Larcom, R.E., LL.D., F.R.S. Richard Griffith, Esq., LL.D., M.R.I.A., F.R.S.E., F.G.S.	Lundy E. Foote, Esq. Rev. Professor Jellett, F.T.C.D. W. Neilson Hancock, LL.D.
RICHARD OWEN, M.D., D.C.L., V.P.R.S., F.L.S., F.G.S., Superintendent of the Natural-History Departments of the British Museum LEEDS, September 22, 1858.	The Lord Monteagle, F.R.S. The Lord Viscount Goderich, M.P., F.R.G.S. The Right Hon. M. T. Baines, M.A., M.P. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. The Rev. W. Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., F.R.A.S., Master of Trinity College, Cambridge James Garth Marshall, Esq., M.A., F.G.S. R. Monckton Milnes, Esq., D.C.L., M.P., F.R.G.S.	Rev. Thomas Hincks, B.A. W. Sykes Ward, Esq., F.C.S. Thomas Wilson, Esq., M.A.
HIS ROYAL HIGHNESS THE PRINCE CONSORT. ABERDEEN, September 14, 1859.	The Duke of Richmond, K.G., F.R.S. The Earl of Aberdeen, LL.D., K.G., K.T., F.R.S. The Lord Provost of the City of Aberdeen Sir John F. W. Herschel, Bart., M.A., D.C.L., F.R.S. Sir David Brewster, K.H., D.C.L., F.R.S. Sir Roderick I. Murchison, G.C.St.S., D.C.L., F.R.S. The Rev. W. V. Harcourt, M.A., F.R.S. The Rev. T. R. Robinson, D.D., F.R.S. A. Thomson, Esq., LL.D., F.R.S., Convener of the County of Aberdeen.	Professor J. Nicol, F.R.S.E., F.G.S. Professor Fuller, M.A. John F. White, Esq.

The LORD WROTTESLEY, M.A., V.P.R.S., F.R.A.S. OXFORD, June 27, 1860.	The Earl of Derby, K.G., P.C., D.C.L., Chancellor of the Univ. of Oxford The Rev. F. Jeune, D.C.L., Vice-Chancellor of the University of Oxford The Duke of Marlborough, D.C.L., F.G.S., Lord Lieutenant of Oxfordshire The Earl of Rosse, K.P., M.A., F.R.S., F.R.A.S. The Lord Bishop of Oxford, D.D., F.R.S. The Very Rev. H. G. Liddell, D.D., Dean of Christ Church, Oxford Professor Daubeny, M.D., LL.D., F.R.S., F.L.S., F.G.S. Professor Acland, M.D., F.R.S. Professor Donkin, M.A., F.R.S., F.R.A.S.	George Rolleston, M.D., F.L.S. H. J. S. Smith, Esq., M.A., F.C.S. George Griffith, Esq., M.A., F.C.S.
WILLIAM FAIRBAIRN, Esq., LL.D., C.E., F.R.S. MANCHESTER, September 4, 1861.	The Earl of Ellesmere, F.R.G.S. The Lord Stanley, M.P., D.C.L., F.R.G.S. The Lord Bishop of Manchester, D.D., F.R.S., F.G.S. Sir Philip de M. Grey Egerton, Bart., M.P., F.R.S., F.G.S. Sir Benjamin Heywood, Bart., F.R.S. Thomas Bazley, Esq., M.P. James Aspinall Turner, Esq., M.P. James Prescott Joule, Esq., LL.D., F.R.S., Pres. Lit. & Phil. Soc. Manchester Professor E. Hodgkinson, F.R.S., M.R.I.A., M.I.C.E. Joseph Whitworth Esq., F.R.S., M.I.C.E.	R. D. Darbishire, Esq., B.A., F.G.S. Alfred Neild, Esq. Arthur Ransome, M.A., Esq. Professor H. E. Roscoe, B.A.
The REV. R. WILLIS, M.A., F.R.S., Jacksonian Professor of Natural and Experimental Philosophy in the University of Cambridge CAMBRIDGE, October 1, 1862.	The Rev. the Vice-Chancellor of the University of Cambridge The Very Rev. Harvey Goodwin, D.D., Dean of Ely The Rev. W. Whewell, D.D., F.R.S., Master of Trinity College, Cambridge The Rev. Professor Sedgwick, M.A., D.C.L., F.R.S. Rev. J. Challis, M.A., F.R.S. G. B. Airy, Esq., M.A., D.C.L., F.R.S., Astronomer Royal Professor G. G. Stokes, M.A., D.C.L., Sec. R.S. Professor J. C. Adams, M.A., D.C.L., F.R.S., Pres. C.P.S.	Professor C. C. Babington, M.A., F.R.S., F.L.S. Professor G. D. Liveing, M.A. The Rev. N. M. Ferrers, M.A.
SIR W. ARMSTRONG, C.B., LL.D., F.R.S. NEWCASTLE-ON-TYNE, August 26, 1863.	Sir Walter C. Trevelyan, Bart., M.A. Sir Charles Lyell, LL.D., D.C.L., F.R.S., F.G.S. Hugh Taylor, Esq., Chairman of the Coal Trade Isaac Lowthian Bell, Esq., Mayor of Newcastle Nicholas Wood, Esq., President of the Northern Institute of Mining Engineers Rev. Temple Chevallier, B.D., F.R.A.S. William Fairbairn, Esq., LL.D., F.R.S.	A. Noble, Esq. Augustus H. Hunt, Esq. R. C. Clapham, Esq.
SIR CHARLES LYELL, Bart., M.A., D.C.L., F.R.S. BATH, September 14, 1864.	The Right Hon. the Earl of Cork and Orrery, Lord Lieutenant of Somersetshire The Most Noble the Marquis of Bath The Right Hon. Earl Nelson The Right Hon. Lord Portman The Very Reverend the Dean of Hereford The Venerable the Archdeacon of Bath W. Tite, Esq., M.P., F.R.S., F.G.S., F.S.A. A. E. Way, Esq., M.P. Francis H. Dickinson, Esq. W. Sanders, Esq., F.R.S., F.G.S.	C. Moore, Esq., F.G.S. C. E. Davis, Esq. The Rev. H. H. Winwood, M.A.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
JOHN PHILLIPS, Esq., M.A., LL.D., F.R.S., F.G.S., Professor of Geology in the University of Oxford BIRMINGHAM, September 6, 1865.	The Right Hon. the Earl of Lichfield, Lord-Lieutenant of Staffordshire. The Right Hon. the Earl of Dudley The Right Hon. Lord Leigh, Lord-Lieutenant of Warwickshire The Right Hon. Lord Lyttelton, Lord-Lieutenant of Worcestershire The Right Hon. Lord Wrottesley, M.A., D.C.L., F.R.S., F.R.A.S. The Right Reverend the Lord Bishop of Worcester The Right Hon. C. B. Adderley, M.P. William Scholefield, Esq., M.P. J. T. Chance, Esq. F. Osler, Esq., F.R.S. The Rev. Charles Evans, M.A.	William Mathews, Esq., jun., F.G.S. John Henry Chamberlain, Esq. The Rev. G. D. Boyle, M.A.
WILLIAM R. GROVE, Esq., Q.C., M.A., F.R.S. NOTTINGHAM, August 22, 1866.	His Grace the Duke of Devonshire, Lord-Lieutenant of Derbyshire His Grace the Duke of Rutland, Lord-Lieutenant of Leicestershire The Right Hon. Lord Belper, Lord-Lieutenant of Nottinghamshire. The Right Hon. J. E. Denison, M.P. J. C. Webb, Esq., High-Sheriff of Nottinghamshire Thomas Graham, Esq., F.R.S., Master of the Mint. Joseph Hooker, M.D., F.R.S., F.L.S. John Russell Hinds, Esq., F.R.S., F.R.A.S. T. Close, Esq.	Dr. Robertson. Edward J. Lowe, Esq., F.R.A.S., F.L.S. The Rev. J. F. M'Callan, M.A.
HIS GRACE THE DUKE OF BUCCLEUCH, K.G., D.C.L., F.R.S. DUNDEE, September 4, 1867.	The Right Hon. the Earl of Airlie, K.T. The Right Hon. the Lord Kinnaird, K.T. Sir John Ogilvy, Bart., M.P. Sir Roderick I. Murchison, Bart., K.C.B., LL.D., F.R.S., F.G.S., &c. Sir David Baxter, Bart. Sir David Brewster, D.C.L., F.R.S., Principal of the University of Edinburgh James D. Forbes, LL.D., F.R.S., Principal of the United College of St. Salvator and St. Leonards, University of St. Andrews	J. Henderson, Esq., jun. John Austin Lake Gloag, Esq. Patrick Anderson, Esq.
JOSEPH DALTON HOOKER, M.D., D.C.L., F.R.S., F.L.S. NORWICH, August 19, 1868.	The Right Hon. the Earl of Leicester, Lord-Lieutenant of Norfolk Sir John Peter Boileau, Bart., F.R.S. The Rev. Adam Sedgwick, M.A., LL.D., F.R.S., F.G.S., &c., Woodwardian Professor of Geology in the University of Cambridge Sir John Lubbock, Bart., F.R.S., F.L.S., F.G.S. John Couch Adams, Esq., M.A., D.C.L., F.R.S., F.R.A.S., Lowndean Professor of Astronomy and Geometry in the University of Cambridge. Thomas Brightwell, Esq.	Dr. Donald Dalrymple. Rev. Joseph Crompton, M.A. Rev. Canon Hinds Howell.
PROFESSOR GEORGE G. STOKES, D.C.L., F.R.S. EXETER, August 18, 1869.	The Right Hon. the Earl of Devon The Right Hon. Sir Stafford H. Northcote, C.B., Bart., M.P., &c. Sir John Bowring, LL.D., F.R.S. William B. Carpenter, M.D., F.R.S., F.L.S. Robert Were Fox, Esq., F.R.S. W. H. Fox Talbot, Esq., M.A., LL.D., F.R.S., F.L.S.	Henry S. Ellis, Esq., F.R.A.S. John C. Bowring, Esq. The Rev. R. Kirwan.

PROFESSOR T. H. HUXLEY, LL.D., F.R.S., F.G.S. LIVERPOOL, September 14, 1870.	The Right Hon. the Earl of Derby, LL.D., F.R.S. Sir Philip De M. Grey Egerton, Bart., M.P. The Right Hon. W. E. Gladstone, D.C.L., M.P. S. R. Graves, Esq., M.P. Sir Joseph Whitworth, Bart., LL.D., D.C.L., F.R.S. James P. Joule, LL.D., D.C.L., F.R.S. Joseph Mayer, Esq., F.S.A., F.R.G.S.	Rev. W. Banister. Reginald Harrison, Esq. Rev. Henry H. Higgins, M.A. Rev. Dr. A. Hume, F.S.A.
PROFESSOR SIR WILLIAM THOMSON, M.A., LL.D., F.R.SS.L. & E. EDINBURGH, August 2, 1871.	His Grace the Duke of Buccleuch, K.G., D.C.L., F.R.S. The Right Hon. the Lord Provost of Edinburgh The Right Hon. John Inglis, LL.D., Lord Justice-General of Scotland. Sir Alexander Grant, Bart., M.A., Principal of the University of Edinburgh Sir Roderick I. Murchison, Bart., K.C.B., G.C.St.S., D.C.L., F.R.S. Sir Charles Lyell, Bart., D.C.L., F.R.S., F.G.S. Dr. Lyon Playfair, M.P., C.B., F.R.S. Professor Christison, M.D., D.C.L., Pres. R.S.E. Professor Balfour, F.R.SS.L. & E.	Professor A. Crum Brown, M.D., F.R.S.E. J. D. Marwick, Esq., F.R.S.E.
DR. W. B. CARPENTER, LL.D., F.R.S., F.L.S. BRIGHTON, August 14, 1872.	The Earl of Chichester, Lord-Lieutenant of the County of Sussex. The Duke of Norfolk. The Right Hon. the Duke of Richmond, K.G., P.C., D.C.L. The Right Hon. the Duke of Devonshire, K.G., D.C.L., F.R.S. Sir John Lubbock, Bart., M.P., F.R.S., F.L.S., F.G.S. Dr. Sharpey, LL.D., Sec. R.S., F.L.S. J. Prestwich, Esq., F.R.S., Pres. G.S.	Charles Carpenter, Esq. The Rev. Dr. Griffith. Henry Willett, Esq.
PROFESSOR ALEXANDER W. WILLIAMSON, LL.D., F.R.S., F.C.S. BRADFORD, September 17, 1873.	The Right Hon. the Earl of Rosse, F.R.S., F.R.A.S. Lord Houghton, D.C.L., F.R.S. The Right Hon. W. E. Forster, M.P. The Mayor of Bradford. J. P. Gassiot, Esq., D.C.L., F.R.S. Professor Phillips, D.C.L., F.R.S. Sir John Hawkshaw, F.R.S., F.G.S.	The Rev. J. R. Campbell, D.D. Richard Goddard, Esq. Peile Thompson, Esq.
PROFESSOR J. TYNDALL, D.C.L., LL.D., F.R.S. BELFAST, August 19, 1874.	The Right Hon. the Earl of Enniskillen, D.C.L., F.R.S. The Right Hon. the Earl of Rosse, F.R.S. Sir Richard Wallace, Bart., M.P. Rev. Dr. Henry. Rev. Dr. Robinson, F.R.S. Dr. Andrews, F.R.S. Professor Stokes, D.C.L., F.R.S.	W. Quartus Ewart, Esq. Dr. T. Redfern. T. Sinclair, Esq.
SIR JOHN HAWKSHAW, C.E., F.R.S., F.G.S. BRISTOL, August 25, 1875.	The Right Hon. the Earl of Ducie, F.R.S., F.G.S. The Right Hon. Sir Stafford H. Northcote, Bart., C.B., M.P., F.R.S. The Mayor of Bristol (1874-75). Major-General Sir Henry C. Rawlinson, K.C.B., LL.D., F.R.S., F.R.G.S. Dr. W. B. Carpenter, LL.D., F.R.S., F.L.S., F.G.S. W. Saunders, Esq., F.R.S., F.G.S.	W. Lant Carpenter, Esq., B.A., B.Sc., F.C.S. John H. Clarke, Esq.

Presidents and Secretaries of the Sections of the Association.

Date and Place.	Presidents.	Secretaries.
MATHEMATICAL AND PHYSICAL SCIENCES.		
COMMITTEE OF SCIENCES, I.—MATHEMATICS AND GENERAL PHYSICS.		
1832. Oxford	Davies Gilbert, D.C.L., F.R.S.	Rev. H. Coddington.
1833. Cambridge	Sir D. Brewster, F.R.S.	Prof. Forbes.
1834. Edinburgh	Rev. W. Whewell, F.R.S.	Prof. Forbes, Prof. Lloyd.
SECTION A.—MATHEMATICS AND PHYSICS.		
1835. Dublin	Rev. Dr. Robinson	Prof. Sir W. R. Hamilton, Prof. Wheatstone.
1836. Bristol	Rev. William Whewell, F.R.S.	Prof. Forbes, W. S. Harris, F. W. Jerrard.
1837. Liverpool	Sir D. Brewster, F.R.S.	W. S. Harris, Rev. Prof. Powell, Prof. Stevelly.
1838. Newcastle	Sir J. F. W. Herschel, Bart., F.R.S.	Rev. Prof. Chevallier, Major Sabine, Prof. Stevelly.
1839. Birmingham	Rev. Prof. Whewell, F.R.S.	J. D. Chance, W. Snow Harris, Prof. Stevelly.
1840. Glasgow	Prof. Forbes, F.R.S.	Rev. Dr. Forbes, Prof. Stevelly, Arch. Smith.
1841. Plymouth	Rev. Prof. Lloyd, F.R.S.	Prof. Stevelly.
1842. Manchester	Very Rev. G. Peacock, D.D., F.R.S.	Prof. M'Culloch, Prof. Stevelly, Rev. W. Scoresby.
1843. Cork	Prof. M'Culloch, M.R.I.A.	J. Nott, Prof. Stevelly.
1844. York	The Earl of Rosse, F.R.S.	Rev. Wm. Hey, Prof. Stevelly.
1845. Cambridge	The Very Rev. the Dean of Ely	Rev. H. Goodwin, Prof. Stevelly, G. G. Stokes.
1846. Southampton	Sir John F. W. Herschel, Bart., F.R.S.	John Drew, Dr. Stevelly, G. G. Stokes.
1847. Oxford	Rev. Prof. Powell, M.A., F.R.S.	Rev. H. Price, Prof. Stevelly, G. G. Stokes.
1848. Swansea	Lord Wrottesley, F.R.S.	Dr. Stevelly, G. G. Stokes.
1849. Birmingham	William Hopkins, F.R.S.	Prof. Stevelly, G. G. Stokes, W. Ridout Wills.
1850. Edinburgh	Prof. J. D. Forbes, F.R.S., Sec. R.S.E.	W. J. Macquorn Rankine, Prof. Smyth, Prof. Stevelly, Prof. G. G. Stokes.
1851. Ipswich	Rev. W. Whewell, D.D., F.R.S., &c.	S. Jackson, W. J. Macquorn Rankine, Prof. Stevelly, Prof. G. G. Stokes.
1852. Belfast	Prof. W. Thomson, M.A., F.R.S. L. & E.	Prof. Dixon, W. J. Macquorn Rankine, Prof. Stevelly, J. Tyndall.
1853. Hull	The Dean of Ely, F.R.S.	B. Blaydes Haworth, J. D. Sollitt, Prof. Stevelly, J. Welsh.
1854. Liverpool	Prof. G. G. Stokes, M.A., Sec. R.S.	J. Hartnup, H. G. Puckle, Prof. Stevelly, J. Tyndall, J. Welsh.
1855. Glasgow	Rev. Prof. Kelland, M.A., F.R.S. L. & E.	Rev. Dr. Forbes, Prof. D. Gray, Prof. Tyndall.
1856. Cheltenham	Rev. R. Walker, M.A., F.R.S.	C. Brooke, Rev. T. A. Southwood, Prof. Stevelly, Rev. J. C. Turnbull.
1857. Dublin	Rev. T. R. Robinson, D.D., F.R.S., M.R.I.A.	Prof. Curtis, Prof. Hennessy, P. A. Ninnis, W. J. Macquorn Rankine, Prof. Stevelly.

Date and Place.	Presidents.	Secretaries.
1858. Leeds	Rev. W. Whewell, D.D., V.P.R.S.	Rev. S. Earnshaw, J. P. Hennessy, Prof. Stevelly, H. J. S. Smith, Prof. Tyndall.
1859. Aberdeen ...	The Earl of Rosse, M.A., K.P., F.R.S.	J. P. Hennessy, Prof. Maxwell, H. J. S. Smith, Prof. Stevelly.
1860. Oxford	Rev. B. Price, M.A., F.R.S.......	Rev. G. C. Bell, Rev. T. Rennison, Prof. Stevelly.
1861. Manchester .	G. B. Airy, M.A., D.C.L., F.R.S.	Prof. R. B. Clifton, Prof. H. J. S. Smith, Prof. Stevelly.
1862. Cambridge ..	Prof. G. G. Stokes, M.A., F.R.S.	Prof. R. B. Clifton, Prof. H. J. S. Smith, Prof. Stevelly.
1863. Newcastle...	Prof. W. J. Macquorn Rankine, C.E., F.R.S.	Rev. N. Ferrers, Prof. Fuller, F. Jenkin, Prof. Stevelly, Rev. C. T. Whitley.
1864. Bath	Prof. Cayley, M.A., F.R.S., F.R.A.S.	Prof. Fuller, F. Jenkin, Rev. G. Buckle, Prof. Stevelly.
1865. Birmingham	W. Spottiswoode, M.A., F.R.S., F.R.A.S.	Rev. T. N. Hutchinson, F. Jenkin, G. S. Mathews, Prof. H. J. S. Smith, J. M. Wilson.
1866. Nottingham	Prof. Wheatstone, D.C.L., F.R.S.	Fleeming Jenkin, Prof. H. J. S. Smith, Rev. S. N. Swann.
1867. Dundee......	Prof. Sir W. Thomson, D.C.L., F.R.S.	Rev. G. Buckle, Prof. G. C. Foster, Prof. Fuller, Prof. Swan.
1868. Norwich ...	Prof. J. Tyndall, LL.D., F.R.S...	Prof. G. C. Foster, Rev. R. Harley, R. B. Hayward.
1869. Exeter	Prof. J. J. Sylvester, LL.D., F.R.S.	Prof. G. C. Foster, R. B. Hayward, W. K. Clifford.
1870. Liverpool ...	J. Clerk Maxwell, M.A., LL.D., F.R.S.	Prof. W. G. Adams, W. K. Clifford, Prof. G. C. Foster, Rev. W. Allen Whitworth.
1871. Edinburgh .	Prof. P. G. Tait, F.R.S.E.	Prof. W. G. Adams, J. T. Bottomley, Prof. W. K. Clifford, Prof. J. D. Everett, Rev. R. Harley.
1872. Brighton ...	W. De La Rue, D.C.L., F.R.S...	Prof. W. K. Clifford, J. W. L. Glaisher, Prof. A. S. Herschel, G. F. Rodwell.
1873. Bradford ...	Prof. H. J. S. Smith, F.R.S......	Prof. W. K. Clifford, Prof. Forbes, J. W. L. Glaisher, Prof. A. S. Herschel.
1874. Belfast	Rev. Prof. J. H. Jellett, M.A., M.R.I.A.	J. W. L. Glaisher, Prof. Herschel, Randal Nixon, J. Perry, G. F. Rodwell.

CHEMICAL SCIENCE.

COMMITTEE OF SCIENCES, II.—CHEMISTRY, MINERALOGY.

1832. Oxford	John Dalton, D.C.L., F.R.S.......	James F. W. Johnston.
1833. Cambridge..	John Dalton, D.C.L., F.R.S.......	Prof. Miller.
1834. Edinburgh...	Dr. Hope..............................	Mr. Johnston, Dr. Christison.

SECTION B.—CHEMISTRY AND MINERALOGY.

1835. Dublin	Dr. T. Thomson, F.R.S.	Dr. Apjohn, Prof. Johnston.
1836. Bristol	Rev. Prof. Cumming...............	Dr. Apjohn, Dr. C. Henry, W. Herapath.
1837. Liverpool...	Michael Faraday, F.R.S.	Prof. Johnston, Prof. Miller, Dr. Reynolds.
1838. Newcastle...	Rev. William Whewell, F.R.S....	Prof. Miller, R. L. Pattinson, Thomas Richardson.
1839. Birmingham	Prof. T. Graham, F.R.S.	Golding Bird, M.D., Dr. J. B. Melson.
1840. Glasgow ...	Dr. Thomas Thomson, F.R.S. ...	Dr. R. D. Thomson, Dr. T. Clark, Dr. L. Playfair.
1841. Plymouth...	Dr. Daubeny, F.R.S.	J. Prideaux, Robert Hunt, W. M. Tweedy.

Date and Place.	Presidents.	Secretaries.
1842. Manchester.	John Dalton, D.C.L., F.R.S.	Dr. L. Playfair, R. Hunt, J. Graham.
1843. Cork	Prof. Apjohn, M.R.I.A.	R. Hunt, Dr. Sweeny.
1844. York	Prof. T. Graham, F.R.S.	Dr. R. Playfair, E. Solly, T. H. Barker.
1845. Cambridge	Rev. Prof. Cumming	R. Hunt, J. P. Joule, Prof. Miller, E. Solly.
1846. Southampton	Michael Faraday, D.C.L., F.R.S.	Dr. Miller, R. Hunt, W. Randall.
1847. Oxford	Rev. W. V. Harcourt, M.A., F.R.S.	B. C. Brodie, R. Hunt, Prof. Solly.
1848. Swansea	Richard Phillips, F.R.S.	T. H. Henry, R. Hunt, T. Williams.
1849. Birmingham	John Percy, M.D., F.R.S.	R. Hunt, G. Shaw.
1850. Edinburgh	Dr. Christison, V.P.R.S.E.	Dr. Anderson, R. Hunt, Dr. Wilson.
1851. Ipswich	Prof. Thomas Graham, F.R.S.	T. J. Pearsall, W. S. Ward.
1852. Belfast	Thomas Andrews, M.D., F.R.S.	Dr. Gladstone, Prof. Hodges, Prof. Ronalds.
1853. Hull	Prof. J. F. W. Johnston, M.A., F.R.S.	H. S. Blundell, Prof. R. Hunt, T. J. Pearsall.
1854. Liverpool	Prof. W. A. Miller, M.D., F.R.S.	Dr. Edwards, Dr. Gladstone, Dr. Price.
1855. Glasgow	Dr. Lyon Playfair, C.B., F.R.S.	Prof. Frankland, Dr. H. E. Roscoe.
1856. Cheltenham	Prof. B. C. Brodie, F.R.S.	J. Horsley, P. J. Worsley, Prof. Voelcker.
1857. Dublin	Prof. Apjohn, M.D., F.R.S., M.R.I.A.	Dr. Davy, Dr. Gladstone, Prof. Sullivan.
1858. Leeds	Sir J. F. W. Herschel, Bart., D.C.L.	Dr. Gladstone, W. Odling, R. Reynolds.
1859. Aberdeen	Dr. Lyon Playfair, C.B., F.R.S.	J. S. Brazier, Dr. Gladstone, G. D. Liveing, Dr. Odling.
1860. Oxford	Prof. B. C. Brodie, F.R.S.	A. Vernon Harcourt, G. D. Liveing, A. B. Northcote.
1861. Manchester.	Prof. W. A. Miller, M.D., F.R.S.	A. Vernon Harcourt, G. D. Liveing.
1862. Cambridge	Prof. W. A. Miller, M.D., F.R.S.	H. W. Elphinstone, W. Odling, Prof. Roscoe.
1863. Newcastle	Dr. Alex. W. Williamson, F.R.S.	Prof. Liveing, H. L. Pattinson, J. C. Stevenson.
1864. Bath	W. Odling, M.B., F.R.S., F.C.S.	A. V. Harcourt, Prof. Liveing, R. Biggs.
1865. Birmingham	Prof. W. A. Miller, M.D., V.P.R.S.	A. V. Harcourt, H. Adkins, Prof. Wanklyn, A. Winkler Wills.
1866. Nottingham	H. Bence Jones, M.D., F.R.S.	J. H. Atherton, Prof. Liveing, W. J. Russell, J. White.
1867. Dundee	Prof. T. Anderson, M.D., F.R.S.E.	A. Crum Brown, Prof. G. D. Liveing, W. J. Russell.
1868. Norwich	Prof. E. Frankland, F.R.S., F.C.S.	Dr. A. Crum Brown, Dr. W. J. Russell, F. Sutton.
1869. Exeter	Dr. H. Debus, F.R.S., F.C.S.	Prof. A. Crum Brown, M.D., Dr. W. J. Russell, Dr. Atkinson.
1870. Liverpool	Prof. H. E. Roscoe, B.A., F.R.S., F.C.S.	Prof. A. Crum Brown, M.D., A. E. Fletcher, Dr. W. J. Russell.
1871. Edinburgh	Prof. T. Andrews, M.D., F.R.S.	J. T. Buchanan, W. N. Hartley, T. E. Thorpe.
1872. Brighton	Dr. J. H. Gladstone, F.R.S.	Dr. Mills, W. Chandler Roberts, Dr. W. J. Russell, Dr. T. Wood.
1873. Bradford	Prof. W. J. Russell, F.R.S.	Dr. Armstrong, Dr. Mills, W. Chandler Roberts, Dr. Thorpe.
1874. Belfast	Prof. A. Crum-Brown, M.D., F.R.S.E., F.C.S.	Dr. T. Cranstoun Charles, W. Chandler Roberts, Prof. Thorpe.

GEOLOGICAL (AND, UNTIL 1851, GEOGRAPHICAL) SCIENCE.

COMMITTEE OF SCIENCES, III.—GEOLOGY AND GEOGRAPHY.

1832. Oxford	R. I. Murchison, F.R.S.	John Taylor.
1833. Cambridge	G. B. Greenough, F.R.S.	W. Lonsdale, John Phillips.
1834. Edinburgh	Prof. Jameson	Prof. Phillips, T. Jameson Torrie, Rev. J. Yates.

SECTION C.—GEOLOGY AND GEOGRAPHY.

Date and Place.	Presidents.	Secretaries.
1835. Dublin	R. J. Griffith	Captain Portlock, T. J. Torrie.
1836. Bristol	Rev. Dr. Buckland, F.R.S.—*Geography*. R. I. Murchison, F.R.S.	William Sanders, S. Stutchbury, T. J. Torrie.
1837. Liverpool...	Rev. Prof. Sedgwick, F.R.S.—*Geography*. G. B. Greenough, F.R.S.	Captain Portlock, R. Hunter.—*Geography*. Captain H. M. Denham, R.N.
1838. Newcastle...	C. Lyell, F.R.S., V.P.G.S.—*Geography*. Lord Prudhope.	W. C. Trevelyan, Capt. Portlock.—*Geography*. Capt. Washington.
1839. Birmingham	Rev. Dr. Buckland, F.R.S.—*Geography*. G. B. Greenough, F.R.S.	George Lloyd, M.D., H. E. Strickland, Charles Darwin.
1840. Glasgow ...	Charles Lyell, F.R.S.—*Geography*. G. B. Greenough, F.R.S.	W. J. Hamilton, D. Milne, Hugh Murray, H. E. Strickland, John Scoular, M.D.
1841. Plymouth ..	H. T. De la Beche, F.R.S.	W. J. Hamilton, Edward Moore, M.D., R. Hutton.
1842. Manchester	R. I. Murchison, F.R.S.	E. W. Binney, R. Hutton, Dr. R. Lloyd, H. E. Strickland.
1843. Cork	Richard E. Griffith, F.R.S., M.R.I.A.	Francis M. Jennings, H. E. Strickland.
1844. York	Henry Warburton, M.P., Pres. Geol. Soc.	Prof. Ansted, E. H. Bunbury.
1845. Cambridge .	Rev. Prof. Sedgwick, M.A., F.R.S.	Rev. J. C. Cumming, A. C. Ramsay, Rev. W. Thorp.
1846. Southampton	Leonard Horner, F.R.S.—*Geography*. G. B. Greenough, F.R.S.	Robert A. Austen, J. H. Norten, M.D., Prof. Oldham.—*Geography*. Dr. C. T. Beke.
1847. Oxford	Very Rev. Dr. Buckland, F.R.S.	Prof. Ansted, Prof. Oldham, A. C. Ramsay, J. Ruskin.
1848. Swansea ...	Sir H. T. De la Beche, C.B., F.R.S.	Starling Benson, Prof. Oldham, Prof. Ramsay.
1849. Birmingham	Sir Charles Lyell, F.R.S., F.G.S.	J. Beete Jukes, Prof. Oldham, Prof. A. C. Ramsay.
1850. Edinburgh *	Sir Roderick I. Murchison, F.R.S.	A. Keith Johnston, Hugh Miller, Professor Nicol.

SECTION C (*continued*).—GEOLOGY.

Date and Place.	Presidents.	Secretaries.
1851. Ipswich ...	William Hopkins, M.A., F.R.S...	C. J. F. Bunbury, G. W. Ormerod, Searles Wood.
1852. Belfast	Lieut.-Col. Portlock, R.E., F.R.S.	James Bryce, James MacAdam, Prof. M'Coy, Prof. Nicol.
1853. Hull	Prof. Sedgwick, F.R.S.	Prof. Harkness, William Lawton.
1854. Liverpool . .	Prof. Edward Forbes, F.R.S. ...	John Cunningham, Prof. Harkness G. W. Ormerod, J. W. Woodall.
1855. Glasgow ...	Sir R. I. Murchison, F.R.S.	James Bryce, Prof. Harkness, Prof. Nicol.
1856. Cheltenham	Prof. A. C. Ramsay, F.R.S.	Rev. P. B. Brodie, Rev. R. Hepworth, Edward Hull, J. Scougall, T. Wright.
1857. Dublin	The Lord Talbot de Malahide ...	Prof. Harkness, Gilbert Sanders, Robert H. Scott.
1858. Leeds	William Hopkins, M.A., LL.D., F.R.S.	Prof. Nicol, H. C. Sorby, E. W. Shaw.
1859. Aberdeen ...	Sir Charles Lyell, LL.D., D.C.L., F.R.S.	Prof. Harkness, Rev. J. Longmuir, H. C. Sorby.
1860. Oxford	Rev. Prof. Sedgwick, LL.D., F.R.S., F.G.S.	Prof. Harkness, Edward Hull, Capt. Woodall.

* At a Meeting of the General Committee held in 1850, it was resolved "That the subject of Geography be separated from Geology and combined with Ethnology, to constitute a separate Section, under the title of the "Geographical and Ethnological Section," for Presidents and Secretaries of which see page xxxvii.

Date and Place.	Presidents.	Secretaries.
1861. Manchester	Sir R. I. Murchison, D.C.L., LL.D., F.R.S., &c.	Prof. Harkness, Edward Hull, T. Rupert Jones, G. W. Ormerod.
1862. Cambridge	J. Beete Jukes, M.A., F.R.S.	Lucas Barrett, Prof. T. Rupert Jones, H. C. Sorby.
1863. Newcastle ...	Prof. Warington W. Smyth, F.R.S., F.G.S.	E. F. Boyd, John Daglish, H. C. Sorby, Thomas Sopwith.
1864. Bath	Prof. J. Phillips, LL.D., F.R.S., F.G.S.	W. B. Dawkins, J. Johnston, H. C. Sorby, W. Pengelly.
1865. Birmingham	Sir R. I. Murchison, Bart., K.C.B.	Rev. P. B. Brodie, J. Jones, Rev. E. Myers, H. C. Sorby, W. Pengelly.
1866. Nottingham	Prof. A. C. Ramsay, LL.D., F.R.S.	R. Etheridge, W. Pengelly, T. Wilson, G. H. Wright.
1867. Dundee......	Archibald Geikie, F.R.S., F.G.S.	Edward Hull, W. Pengelly, Henry Woodward.
1868. Norwich ...	R. A. C. Godwin-Austen, F.R.S., F.G.S.	Rev. O. Fisher, Rev. J. Gunn, W. Pengelly, Rev. H. H. Winwood.
1869. Exeter	Prof. R. Harkness, F.R.S., F.G.S.	W. Pengelly, W. Boyd Dawkins, Rev. H. H. Winwood.
1870. Liverpool...	Sir Philip de M. Grey Egerton, Bart., M.P., F.R.S.	W. Pengelly, Rev. H. H. Winwood, W. Boyd Dawkins, G. H. Morton.
1871. Edinburgh ..	Prof. A. Geikie, F.R.S., F.G.S...	R. Etheridge, J. Geikie, J. McKenny Hughes, L. C. Miall.
1872. Brighton ...	R. A. C. Godwin-Austen, F.R.S.	L. C. Miall, George Scott, William Topley, Henry Woodward.
1873. Bradford ...	Prof. J. Phillips, D.C.L., F.R.S., F.G.S.	L. C. Miall, R. H. Tiddeman, W. Topley.
1874. Belfast	Prof. Hull, M.A., F.R.S., F.G.S.	F. Drew, L. C. Miall, R. G. Symes, R. H. Tiddeman.

BIOLOGICAL SCIENCES.

COMMITTEE OF SCIENCES, IV.—ZOOLOGY, BOTANY, PHYSIOLOGY, ANATOMY.

1832. Oxford	Rev. P. B. Duncan, F.G.S.	Rev. Prof. J. S. Henslow.
1833. Cambridge*	Rev. W. L. P. Garnons, F.L.S....	C. C. Babington, D. Don.
1834. Edinburgh	Prof. Graham........................	W. Yarrell, Prof. Burnett.

SECTION D.—ZOOLOGY AND BOTANY.

1835. Dublin	Dr. Allman..........................	J. Curtis, Dr. Litton.
1836. Bristol	Rev. Prof. Henslow	J. Curtis, Prof. Don, Dr. Riley, S. Rootsey.
1837. Liverpool ...	W. S. MacLeay	C. C. Babington, Rev. L. Jenyns, W. Swainson.
1838. Newcastle...	Sir W. Jardine, Bart..............	J. E. Gray, Prof. Jones, R. Owen, Dr. Richardson.
1839. Brimingham	Prof. Owen, F.R.S.	E. Forbes, W. Ick, R. Patterson.
1840. Glasgow ...	Sir W. J. Hooker, LL.D	Prof. W. Couper, E. Forbes, R. Patterson.
1841. Plymouth...	John Richardson, M.D., F.R.S...	J. Couch, Dr. Lankester, R. Patterson.
1842. Manchester	Hon. and Very Rev. W. Herbert, LL.D., F.L.S.	Dr. Lankester, R. Patterson, J. A. Turner.
1843. Cork	William Thompson, F.L.S.	G. J. Allman, Dr. Lankester, R. Patterson.
1844. York.........	Very Rev. The Dean of Manchester.	Prof. Allman, H. Goodsir, Dr. King, Dr. Lankester.
1845. Cambridge	Rev. Prof. Henslow, F.L.S.	Dr. Lankester, T. V. Wollaston.
1846. Southampton	Sir J. Richardson, M.D., F.R.S.	Dr. Lankester, T. V. Wollaston, H. Wooldridge.
1847. Oxford.......	H. E. Strickland, M.A., F.R.S....	Dr. Lankester, Dr. Melville, T. V. Wollaston.

* At this Meeting Physiology and Anatomy were made a separate Committee, for Presidents and Secretaries of which see p. xxxvi.

Date and Place.	Presidents.	Secretaries.

SECTION D (*continued*).—ZOOLOGY AND BOTANY, INCLUDING PHYSIOLOGY.

[For the Presidents and Secretaries of the Anatomical and Physiological Subsections and the temporary Section E of Anatomy and Medicine, see p. xxxvi.]

Date and Place.	Presidents.	Secretaries.
1848. Swansea ...	L. W. Dillwyn, F.R.S.	Dr. R. Wilbraham Falconer, A. Henfrey, Dr. Lankester.
1849. Birmingham	William Spence, F.R.S.............	Dr. Lankester, Dr. Russell.
1850. Edinburgh..	Prof. Goodsir, F.R.S. L. & E. ...	Prof. J. H. Bennett, M.D., Dr. Lankester, Dr. Douglas Maclagan.
1851. Ipswich......	Rev. Prof. Henslow, M.A., F.R.S.	Prof. Allman, F. W. Johnston, Dr. E. Lankester.
1852. Belfast	W. Ogilby	Dr. Dickie, George C. Hyndman, Dr. Edwin Lankester.
1853. Hull	C. C. Babington, M.A., F.R.S....	Robert Harrison, Dr. E. Lankester.
1854. Liverpool ...	Prof. Balfour, M.D., F.R.S.......	Isaac Byerley, Dr. E. Lankester.
1855. Glasgow ...	Rev. Dr. Fleeming, F.R.S.E. ...	William Keddie, Dr. Lankester.
1856. Cheltenham.	Thomas Bell, F.R.S., Pres.L.S....	Dr. J. Abercrombie, Prof. Buckman, Dr. Lankester.
1857. Dublin	Prof. W. H. Harvey, M.D., F.R.S.	Prof. J. R. Kinahan, Dr. E. Lankester, Robert Patterson, Dr. W. E. Steele.
1858. Leeds.........	C. C. Babington, M.A., F.R.S....	Henry Denny, Dr. Heaton, Dr. E. Lankester, Dr. E. Perceval Wright.
1859. Aberdeen ...	Sir W. Jardine, Bart., F.R.S.E..	Prof. Dickie, M.D., Dr. E. Lankester, Dr. Ogilvy.
1860. Oxford	Rev. Prof. Henslow, F.L.S.	W. S. Church, Dr. E. Lankester, P. L. Sclater, Dr. E. Perceval Wright.
1861. Manchester..	Prof. C. C. Babington, F.R.S....	Dr. T. Alcock, Dr. E. Lankester, Dr. P. L. Sclater, Dr. E. P. Wright.
1862. Cambridge...	Prof. Huxley, F.R.S.	Alfred Newton, Dr. E. P. Wright.
1863. Newcastle ...	Prof. Balfour, M.D., F.R.S.	Dr. E. Charlton, A. Newton, Rev. H. B. Tristram, Dr. E. P. Wright.
1864. Bath	Dr. John E. Gray, F.R.S.	H. B. Brady, C. E. Broom, H. T. Stainton, Dr. E. P. Wright.
1865. Birmingham	T. Thomson, M.D., F.R.S.	Dr. J. Anthony, Rev. C. Clarke, Rev. H. B. Tristram, Dr. E. P. Wright.

SECTION D (*continued*).—BIOLOGY*.

Date and Place.	Presidents.	Secretaries.
1866. Nottingham.	Prof. Huxley, LL.D., F.R.S.—*Physiological Dep.* Prof. Humphry, M.D., F.R.S.—*Anthropological Dep.* Alfred R. Wallace, F.R.G.S.	Dr. J. Beddard, W. Felkin, Rev. H. B. Tristram, W. Turner, E. B. Tylor, Dr. E. P. Wright.
1867. Dundee	Prof. Sharpey, M.D., Sec. R.S.—*Dep. of Zool. and Bot.* George Busk, M.D., F.R.S.	C. Spence Bate, Dr. S. Cobbold, Dr. M. Foster, H. T. Stainton, Rev. H. B. Tristram, Prof. W. Turner.
1868. Norwich ...	Rev. M. J. Berkeley, F.L.S.—*Dep. of Physiology.* W. H. Flower, F.R.S.	Dr. T. S. Cobbold, G. W. Firth, Dr. M. Foster, Prof. Lawson, H. T. Stainton, Rev. Dr. H. B. Tristram, Dr. E. P. Wright.
1869. Exeter	George Busk, F.R.S., F.L.S.—*Dep. of Bot. and Zool.* C. Spence Bate, F.R.S.—*Dep. of Ethno.* E. B. Tylor.	Dr. T. S. Cobbold, Prof. M. Foster, M.D., E. Ray Lankester, Professor Lawson, H. T. Stainton, Rev. H. B. Tristram.

* At a Meeting of the General Committee in 1865, it was resolved:—"That the title of Section D be changed to Biology;" and "That for the word 'Subsection,' in the rules for conducting the business of the Sections, the word 'Department' be substituted,

Date and Place.	Presidents.	Secretaries.
1870. Liverpool ...	Prof. G. Rolleston, M.A., M.D., F.R.S., F.L.S.—*Dep. Anat. and Physiol.* Prof. M. Foster, M.D., F.L.S.—*Dep. of Ethno.* J. Evans, F.R.S.	Dr. T. S. Cobbold, Sebastian Evans, Prof. Lawson, Thos. J. Moore, H. T. Stainton, Rev. H. B. Tristram, C. Staniland Wake, E. Ray Lankester.
1871. Edinburgh	Prof. Allen Thomson, M.D., F.R.S. —*Dep. of Bot. and Zool.* Prof. Wyville Thomson, F.R.S.—*Dep. of Anthropol.* Prof. W. Turner, M.D.	Dr. T. R. Fraser, Dr. Arthur Gamgee, E. Ray Lankester, Prof. Lawson, H. T. Stainton, C. Staniland Wake, Dr. W. Rutherford, Dr. Kelburne King.
1872. Brighton ...	Sir John Lubbock, Bart., F.R.S. —*Dep. of Anat. and Physiol.* Dr. Burdon Sanderson, F.R.S. —*Dep of Anthropol.* Col. A. Lane Fox, F.G.S.	Prof. Thiselton-Dyer, H. T. Stainton, Prof. Lawson, F. W. Rudler, J. H. Lamprey, Dr. Gamgee, E. Ray Lankester, Dr. Pye-Smith.
1873. Bradford ...	Prof. Allman, F.R.S.—*Dep. of Anat. and Physiol.* Prof. Rutherford, M.D.—*Dep. of Anthropol.* Dr. Beddoe, F.R.S.	Prof. Thiselton-Dyer, Prof. Lawson, R. M'Lachlan, Dr. Pye-Smith, E. Ray Lankester, F. W. Rudler, J. H. Lamprey.
1874. Belfast	Prof. Redfern, M.D.—*Dep. of Zool. and Bot.* Dr. Hooker, C.B., Pres. R.S.—*Dep. of Anthropol.* Sir W. R. Wilde, M.D.	W. T. Thiselton-Dyer, R. O. Cunningham, Dr. J. J. Charles, Dr. P. H. Pye-Smith, J. J. Murphy, F. W. Rudler.

ANATOMICAL AND PHYSIOLOGICAL SCIENCES.

COMMITTEE OF SCIENCES, V.—ANATOMY AND PHYSIOLOGY.

1833. Cambridge...	Dr. Haviland	Dr. Bond, Mr. Paget.
1834. Edinburgh...	Dr. Abercrombie	Dr. Roget, Dr. William Thomson.

SECTION E. (UNTIL 1847.)—ANATOMY AND MEDICINE.

1835. Dublin	Dr. Pritchard	Dr. Harrison, Dr. Hart.
1836. Bristol	Dr. Roget, F.R.S.	Dr. Symonds.
1837. Liverpool ...	Prof. W. Clark, M.D.	Dr. J. Carson, jun., James Long, Dr. J. R. W. Vose.
1838. Newcastle ...	T. E. Headlam, M.D.	T. M. Greenhow, Dr. J. R. W. Vose.
1839. Birmingham	John Yelloly, M.D., F.R.S.	Dr. G. O. Rees, F. Ryland.
1840. Glasgow ...	James Watson, M.D...............	Dr. J. Brown, Prof. Couper, Prof. Reid.
1841. Plymouth...	P. M. Roget, M.D., Sec.R.S. ...	Dr. J. Butter, J. Fuge, Dr. R. S. Sargent.
1842. Manchester.	Edward Holme, M.D., F.L.S. ...	Dr. Chaytor, Dr. R. S. Sargent.
1843. Cork	Sir James Pitcairn, M.D.	Dr. John Popham, Dr. R. S. Sargent.
1844. York	J. C. Pritchard, M.D.	I. Erichsen, Dr. R. S. Sargent.

SECTION E.—PHYSIOLOGY.

1845. Cambridge .	Prof. J. Haviland, M.D.	Dr. R. S. Sargent, Dr. Webster.
1846. Southampton	Prof. Owen, M.D., F.R.S.........	C. P. Keele, Dr. Laycock, Dr. Sargent.
1847. Oxford* ...	Prof. Ogle, M.D., F.R.S.	Dr. Thomas K. Chambers, W. P. Ormerod.

PHYSIOLOGICAL SUBSECTIONS OF SECTION D.

1850. Edinburgh	Prof. Bennett, M.D., F.R.S.E.	
1855. Glasgow ...	Prof. Allen Thomson, F.R.S. ...	Prof. J. H. Corbett, Dr. J. Struthers.
1857. Dublin	Prof. R. Harrison, M.D.	Dr. R. D. Lyons, Prof. Redfern.

* By direction of the General Committee at Oxford, Sections D and E were incorporated under the name of "Section D—Zoology and Botany, including Physiology" (see p. xxxiv). The Section being then vacant was assigned in 1851 to Geography.

Date and Place.	Presidents.	Secretaries.
1858. Leeds	Sir Benjamin Brodie, Bart. F.R.S.	C. G. Wheelhouse.
1859. Aberdeen ...	Prof. Sharpey, M.D., Sec.R.S. ...	Prof. Bennett, Prof. Redfern.
1860. Oxford	Prof. G. Rolleston, M.D., F.L.S.	Dr. R. M'Donnell, Dr. Edward Smith.
1861. Manchester.	Dr. John Davy, F.R.S.L. & E....	Dr. W. Roberts, Dr. Edward Smith.
1862. Cambridge .	C. E. Paget, M.D.	G. F. Helm, Dr. Edward Smith.
1863. Newcastle...	Prof. Rolleston, M.D., F.R.S. ...	Dr. D. Embleton, Dr. W. Turner.
1864. Bath	Dr. Edward Smith, LL.D., F.R.S.	J. S. Bartrum, Dr. W. Turner.
1865. Birminghm*.	Prof. Acland, M.D., LL.D., F.R.S.	Dr. A. Fleming, Dr. P. Heslop, Oliver Pembleton, Dr. W. Turner.

GEOGRAPHICAL AND ETHNOLOGICAL SCIENCES.

[For Presidents and Secretaries for Geography previous to 1851, see Section C, p. xxxii.]

ETHNOLOGICAL SUBSECTIONS OF SECTION D.

1846. Southampton	Dr. Pritchard	Dr. King.
1847. Oxford	Prof. H. H. Wilson, M.A.	Prof. Buckley.
1848. Swansea ...	....	G. Grant Francis.
1849. Birmingham	....	Dr. R. G. Latham.
1850. Edinburgh..	Vice-Admiral Sir A. Malcolm ...	Daniel Wilson.

SECTION E.—GEOGRAPHY AND ETHNOLOGY.

1851. Ipswich ...	Sir R. I. Murchison, F.R.S., Pres. R.G.S.	R. Cull, Rev. J. W. Donaldson, Dr. Norton Shaw.
1852. Belfast	Col. Chesney, R.A., D.C.L., F.R.S.	R. Cull, R. MacAdam, Dr. Norton Shaw.
1853. Hull	R. G. Latham, M.D., F.R.S. ...	R. Cull, Rev. H. W. Kemp, Dr. Norton Shaw.
1854. Liverpool...	Sir R. I. Murchison, D.C.L., F.R.S.	Richard Cull, Rev. H. Higgins, Dr. Ihne, Dr. Norton Shaw.
1855. Glasgow ...	Sir J. Richardson, M.D., F.R.S.	Dr. W. G. Blackie, R. Cull, Dr. Norton Shaw.
1856. Cheltenham	Col. Sir H. C. Rawlinson, K.C.B.	R. Cull, F. D. Hartland, W. H. Rumsey, Dr. Norton Shaw.
1857. Dublin	Rev. Dr. J. Henthawn Todd, Pres. R.I.A.	R. Cull, S. Ferguson, Dr. R. R. Madden, Dr. Norton Shaw.
1858. Leeds	Sir R. I. Murchison, G.C.St.S., F.R.S.	R. Cull, Francis Galton, P. O'Callaghan, Dr. Norton Shaw, Thomas Wright.
1859. Aberdeen ...	Rear-Admiral Sir James Clerk Ross, D.C.L., F.R.S.	Richard Cull, Professor Geddes, Dr. Norton Shaw.
1860. Oxford	Sir R. I. Murchison, D.C.L., F.R.S.	Capt. Burrows, Dr. J. Hunt, Dr. C. Lempriere, Dr. Norton Shaw.
1861. Manchester.	John Crawfurd, F.R.S.	Dr. J. Hunt, J. Kingsley, Dr. Norton Shaw, W. Spottiswoode.
1862. Cambridge .	Francis Galton, F.R.S.	J. W. Clarke, Rev. J. Glover, Dr. Hunt, Dr. Norton Shaw, T. Wright.
1863. Newcastle...	Sir R. I. Murchison, K.C.B., F.R.S.	C. Carter Blake, Hume Greenfield, C. R. Markham, R. S. Watson.
1864. Bath	Sir R. I. Murchison, K.C.B., F.R.S.	H. W. Bates, C. R. Markham, Capt. R. M. Murchison, T. Wright.
1865. Birmingham	Major-General Sir R. Rawlinson, M.P., K.C.B., F.R.S.	H. W. Bates, S. Evans, G. Jabet, C. R. Markham, Thomas Wright.
1866. Nottingham	Sir Charles Nicholson, Bart., LL.D.	H. W. Bates, Rev. E. T. Cusins, P. H. Major, Clements R. Markham, D. W. Nash, T. Wright.
1867. Dundee......	Sir Samuel Baker, F.R.G.S.	H. W. Bates, Cyril Graham, C. R. Markham, S. J. Mackie, R. Sturrock.
1868. Norwich ...	Capt. G. H. Richards, R.N., F.R.S.	T. Baines, H. W. Bates, C. R. Markham, T. Wright.

* *Vide* note on page xxxv.

Date and Place.	Presidents.	Secretaries.
	SECTION E (*continued*).—GEOGRAPHY.	
1869. Exeter	Sir Bartle Frere, K.C.B., LL.D., F.R.G.S.	H. W. Bates, Clements R. Markham, J. H. Thomas.
1870. Liverpool ...	Sir R. I. Murchison, Bt., K.C.B., LL.D., D.C.L., F.R.S., F.G.S.	H. W. Bates, David Buxton, Albert J. Mott, Clements R. Markham.
1871. Edinburgh.	Colonel Yule, C.B., F.R.G.S. ...	Clements R. Markham, A. Buchan, J. H. Thomas, A. Keith Johnston.
1872. Brighton ...	Francis Galton, F.R.S.	H. W. Bates, A. Keith Johnston, Rev. J. Newton, J. H. Thomas.
1873. Bradford ...	Sir Rutherford Alcock, K.C.B....	H. W. Bates, A. Keith Johnston, Clements R. Markham.
1874. Belfast	Major Wilson, R.E., F.R.S., F.R.G.S.	E. G. Ravenstein, E. C. Rye.

STATISTICAL SCIENCE.

	COMMITTEE OF SCIENCES, VI.—STATISTICS.	
1833. Cambridge .	Prof. Babbage, F.R.S.	J. E. Drinkwater.
1834. Edinburgh .	Sir Charles Lemon, Bart.	Dr. Cleland, C. Hope Maclean.

	SECTION F.—STATISTICS.	
1835. Dublin	Charles Babbage, F.R.S.	W. Greg, Prof. Longfield.
1836. Bristol	Sir Charles Lemon, Bart., F.R.S.	Rev. J. E. Bromby, C. B. Fripp, James Heywood.
1837. Liverpool ...	Rt. Hon. Lord Sandon	W. R. Greg, W. Langton, Dr. W. C. Tayler.
1838. Newcastle...	Colonel Sykes, F.R.S.	W. Cargill, J. Heywood, W. R. Wood.
1839. Birmingham	Henry Hallam, F.R.S.	F. Clarke, R. W. Rawson, Dr. W. C. Tayler.
1840. Glasgow ...	Rt. Hon. Lord Sandon, F.R.S., M.P.	C. R. Baird, Prof. Ramsay, R. W. Rawson.
1841. Plymouth...	Lieut.-Col. Sykes, F.R.S.	Rev. Dr. Byrth, Rev. R. Luney, R. W. Rawson.
1842. Manchester.	G. W. Wood, M.P., F.L.S.	Rev. R. Luney, G. W. Ormerod, Dr. W. C. Tayler.
1843. Cork	Sir C. Lemon, Bart., M.P.	Dr. D. Bullen, Dr. W. Cooke Tayler.
1844. York	Lieut.-Col. Sykes, F.R.S., F.L.S.	J. Fletcher, J. Heywood, Dr. Laycock.
1845. Cambridge .	Rt. Hon. The Earl Fitzwilliam...	J. Fletcher, W. Cooke Tayler, LL.D.
1846. Southampton	G. R. Porter, F.R.S.	J. Fletcher, F. G. P. Neison, Dr. W. C. Tayler, Rev. T. L. Shapcott.
1847. Oxford	Travers Twiss, D.C.L., F.R.S. ...	Rev. W. H. Cox, J. J. Danson, F. G. P. Neison.
1848. Swansea ...	J. H. Vivian, M.P., F.R.S.	J. Fletcher, Capt. R. Shortrede.
1849. Birmingham	Rt. Hon. Lord Lyttelton	Dr. Finch, Prof. Hancock, F. G. P. Neison.
1850. Edinburgh ..	Very Rev. Dr. John Lee, V.P.R.S.E.	Prof. Hancock, J. Fletcher, Dr. J. Stark.
1851. Ipswich......	Sir John P. Boileau, Bart.	J. Fletcher, Prof. Hancock.
1852. Belfast	His Grace the Archbishop of Dublin.	Prof. Hancock, Prof. Ingram, James MacAdam, Jun.
1853. Hull	James Heywood, M.P., F.R.S....	Edward Cheshire, William Newmarch.
1854. Liverpool ...	Thomas Tooke, F.R.S.	E. Cheshire, J. T. Danson, Dr. W. H. Duncan, W. Newmarch.
1855. Glasgow	R. Monckton Milnes, M.P.	J. A. Campbell, E. Cheshire, W. Newmarch, Prof. R. H. Walsh.

	SECTION F (*continued*).—ECONOMIC SCIENCE AND STATISTICS.	
1856. Cheltenham	Rt. Hon. Lord Stanley, M.P. ...	Rev. C. H. Bromby, E. Cheshire, Dr. W. N. Hancock Newmarch, W. M. Tartt.

Date and Place.	Presidents.	Secretaries.
1857. Dublin	His Grace the Archbishop of Dublin, M.R.I.A.	Prof. Cairns, Dr. H. D. Hutton, W. Newmarch.
1858. Leeds.........	Edward Baines	T. B. Baines, Prof. Cairns, S. Brown, Capt. Fishbourne, Dr. J. Strang.
1859. Aberdeen ...	Col. Sykes, M.P., F.R.S.	Prof. Cairns, Edmund Macrory, A. M. Smith, Dr. John Strang.
1860. Oxford	Nassau W. Senior, M.A.	Edmund Macrory, W. Newmarch, Rev. Prof. J. E. T. Rogers.
1861. Manchester	William Newmarch, F.R.S.	David Chadwick, Prof. R. C. Christie, E. Macrory, Rev. Prof. J. E. T. Rogers.
1862. Cambridge..	Edwin Chadwick, C.B.	H. D. Macleod, Edmund Macrory.
1863. Newcastle ...	William Tite, M.P., F.R.S.	T. Doubleday, Edmund Macrory, Frederick Purdy, James Potts.
1864. Bath..........	William Farr, M.D., D.C.L., F.R.S.	E. Macrory, E. T. Payne, F. Purdy.
1865. Birmingham	Rt. Hon. Lord Stanley, LL.D., M.P.	G. J. D. Goodman, G. J. Johnston, E. Macrory.
1866. Nottingham	Prof. J. E. T. Rogers..............	R. Birkin, Jun., Prof. Leone Levi, E. Macrory.
1867. Dundee	M. E. Grant Duff, M.P.	Prof. Leone Levi, E. Macrory, A. J. Warden.
1868. Norwich ...	Samuel Brown, Pres. Instit. Actuaries.	Rev. W. C. Davie, Prof. Leone Levi.
1869. Exeter	Rt. Hon. Sir Stafford H. Northcote, Bart., C.B., M.P.	Edmund Macrory, Frederick Purdy, Charles T. D. Acland.
1870. Liverpool...	Prof. W. Stanley Jevons, M.A. ..	Chas. R. Dudley Baxter, E. Macrory, J. Miles Moss.
1871. Edinburgh	Rt. Hon. Lord Neaves............	J. G. Fitch, James Meikle.
1872. Brighton ...	Prof. Henry Fawcett, M.P.	J. G. Fitch, Barclay Phillips.
1873. Bradford ...	Rt. Hon. W. E. Forster, M.P....	J. G. Fitch, Swire Smith.
1874. Belfast	Lord O'Hagan.	Prof. Donnell, Frank P. Fellows, Hans MacMordie.

MECHANICAL SCIENCE.

SECTION G.—MECHANICAL SCIENCE.

1836. Bristol	Davies Gilbert, D.C.L., F.R.S....	T. G. Bunt, G. T. Clark, W. West.
1837. Liverpool ...	Rev. Dr. Robinson	Charles Vignoles, Thomas Webster.
1838. Newcastle ...	Charles Babbage, F.R.S.	R. Hawthorn, C. Vignoles, T. Webster.
1839. Birmingham	Prof. Willis, F.R.S., and Robert Stephenson.	W. Carpmael, William Hawkes, Thomas Webster.
1840. Glasgow ...	Sir John Robinson..................	J. Scott Russell, J. Thomson, J. Tod, C. Vignoles.
1841. Plymouth...	John Taylor, F.R.S.	Henry Chatfield, Thomas Webster.
1842. Manchester .	Rev. Prof. Willis, F.R.S.	J. F. Bateman, J. Scott Russell, J. Thomson, Charles Vignoles.
1843. Cork	Prof. J. Macneill, M.R.I.A.......	James Thomson, Robert Mallet.
1844. York	John Taylor, F.R.S.	Charles Vignoles, Thomas Webster.
1845. Cambridge ..	George Rennie, F.R.S.	Rev. W. T. Kingsley.
1846. Southampton	Rev. Prof. Willis, M.A., F.R.S. .	William Betts, Jun., Charles Manby.
1847. Oxford	Rev. Prof. Walker, M.A., F.R.S.	J. Glynn, R. A. Le Mesurier.
1848. Swansea	Rev. Prof. Walker, M.A., F.R.S.	R. A. Le Mesurier, W. P. Struvé.
1849. Birmingham	Robert Stephenson, M.P., F.R.S.	Charles Manby, W. P. Marshall.
1850. Edinburgh ..	Rev. Dr. Robinson	Dr. Lees, David Stephenson.
1851. Ipswich......	William Cubitt, F.R.S............	John Head, Charles Manby.
1852. Belfast	John Walker, C.E., LL.D., F.R.S.	John F. Bateman, C. B. Hancock, Charles Manby, James Thomson.
1853. Hull	William Fairbairn, C.E., F.R.S..	James Oldham, J. Thomson, W. Sykes Ward.
1854. Liverpool ...	John Scott Russell, F.R.S.	John Grantham, J. Oldham, J. Thomson.

Date and Place.	Presidents.	Secretaries.
1855. Glasgow ...	W. J. Macquorn Rankine, C.E., F.R.S.	L. Hill, Jun., William Ramsay, Thomson.
1856. Cheltenham	George Rennie, F.R.S.	C. Atherton, B. Jones, Jun., H. M. Jeffery.
1857. Dublin	The Right Hon. The Earl of Rosse, F.R.S.	Prof. Downing, W. T. Doyne, A. Tate, James Thomson, Henry Wright.
1858. Leeds.........	William Fairbairn, F.R.S.	J. C. Dennis, J. Dixon, H. Wright.
1859. Aberdeen ...	Rev. Prof. Willis, M.A., F.R.S. .	R. Abernethy, P. Le Neve Foster, H. Wright.
1860. Oxford	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	P. Le Neve Foster, Rev. F. Harrison, Henry Wright.
1861. Manchester .	J. F. Bateman, C.E., F.R.S.......	P. Le Neve Foster, John Robinson, H. Wright.
1862. Cambridge ..	William Fairbairn, LL.D., F.R.S.	W. M. Fawcett, P. Le Neve Foster.
1863. Newcastle ...	Rev. Prof. Willis, M.A., F.R.S. .	P. Le Neve Foster, P. Westmacott, J. F. Spencer.
1864. Bath	J. Hawkshaw, F.R.S.	P. Le Neve Foster, Robert Pitt.
1865. Birmingham	Sir W. G. Armstrong, LL.D., F.R.S.	P. Le Neve Foster, Henry Lea, W. P. Marshall, Walter May.
1866. Nottingham	Thomas Hawksley, V.P.Inst. C.E., F.G.S.	P. Le Neve Foster, J. F. Iselin, M. A. Tarbottom.
1867. Dundee	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	P. Le Neve Foster, John P. Smith, W. W Urquhart.
1868. Norwich ...	G. P. Bidder, C.E., F.R.G.S. ...	P. Le Neve Foster, J. F. Iselin, C. Manby, W. Smith.
1869. Exeter	C. W. Siemens, F.R.S.	P. Le Neve Foster, H. Bauerman.
1870. Liverpool ...	Chas. B. Vignoles, C.E., F.R.S. .	H. Bauerman, P. Le Neve Foster, T. King, J. N. Shoolbred.
1871. Edinburgh	Prof. Fleeming Jenkin, F.R.S....	H. Bauerman, Alexander Leslie, J. P. Smith.
1872. Brighton ...	F. J. Bramwell, C.E...............	H. M. Brunel, P. Le Neve Foster, J. G. Gamble, J. N. Shoolbred.
1873. Bradford ...	W. H. Barlow, F.R.S.	Crawford Barlow, H. Bauerman, S. H. Carbutt, J. C. Hawkshaw, J. N. Shoolbred.
1874. Belfast	Prof. James Thomson, LL.D., C.E., F.R.S.E.	A. T. Atchison, J. N. Shoolbred, John Smyth, jun.

List of Evening Lectures.

Date and Place.	Lecturer.	Subject of Discourse.
1842. Manchester .	Charles Vignoles, F.R.S.........	The Principles and Construction of Atmospheric Railways.
	Sir M. I. Brunel	The Thames Tunnel.
	R. I. Murchison.	The Geology of Russia.
1843. Cork	Prof. Owen, M.D., F.R.S.	The Dinornis of New Zealand.
	Prof. E. Forbes, F.R.S.	The Distribution of Animal Life in the Ægean Sea.
	Dr. Robinson	The Earl of Rosse's Telescope.
1844. York	Charles Lyell, F.R.S.	Geology of North America.
	Dr. Falconer, F.R.S.	The Gigantic Tortoise of the Siwalik Hills in India.
1845. Cambridge ..	G. B. Airy, F.R.S., Astron. Royal	Progress of Terrestrial Magnetism.
	R. I. Murchison, F.R.S.........	Geology of Russia.
1846. Southampton	Prof. Owen, M.D., F.R.S.	Fossil Mammalia of the British Isles.
	Charles Lyell, F.R.S.	Valley and Delta of the Mississippi.

Date and Place.	Lecturer.	Subject of Discourse.
1846. Southampton	W. R. Grove, F.R.S.	Properties of the Explosive substance discovered by Dr. Schönbein; also some Researches of his own on the Decomposition of Water by Heat.
1847. Oxford	Rev. Prof. B. Powell, F.R.S. ...	Shooting-stars.
	Prof. M. Faraday, F.R.S.	Magnetic and Diamagnetic Phenomena.
	Hugh E. Strickland, F.G.S. ...	The Dodo (*Didus ineptus*).
1848. Swansea ...	John Percy, M.D., F.R.S.	Metallurgical operations of Swansea and its neighbourhood.
	W. Carpenter, M.D., F.R.S. ...	Recent Microscopical Discoveries.
1849. Birmingham	Dr. Faraday, F.R.S................	Mr. Gassiot's Battery.
	Rev. Prof. Willis, M.A., F.R.S.	Transit of different Weights with varying velocities on Railways.
1850. Edinburgh.	Prof. J. H. Bennett, M.D., F.R.S.E.	Passage of the Blood through the minute vessels of Animals in connexion with Nutrition.
	Dr. Mantell, F.R.S................	Extinct Birds of New Zealand.
1851. Ipswich......	Prof. R. Owen, M.D., F.R.S.	Distinction between Plants and Animals, and their changes of Form.
	G. B. Airy, F.R.S., Astron. Roy.	Total Solar Eclipse of July 28, 1851.
1852. Belfast	Prof. G.G. Stokes, D.C.L., F.R.S.	Recent discoveries in the properties of Light.
	Colonel Portlock, R.E., F.R.S.	Recent discovery of Rock-salt at Carrickfergus, and geological and practical considerations connected with it.
1853. Hull	Prof. J. Phillips, LL.D., F.R.S., F.G.S.	Some peculiar phenomena in the Geology and Physical Geography of Yorkshire.
	Robert Hunt, F.R.S.	The present state of Photography.
1854. Liverpool ...	Prof. R. Owen, M.D., F.R.S. ...	Anthropomorphous Apes.
	Col. E. Sabine, V.P.R.S.	Progress of researches in Terrestrial Magnetism.
1855. Glasgow......	Dr. W. B. Carpenter, F.R.S. ...	Characters of Species.
	Lieut.-Col. H. Rawlinson	Assyrian and Babylonian Antiquities and Ethnology.
1856. Cheltenham	Col. Sir H. Rawlinson	Recent discoveries in Assyria and Babylonia, with the results of Cuneiform research up to the present time.
	W. R. Grove, F.R.S.	Correlation of Physical Forces.
1857. Dublin	Prof. W. Thomson, F.R.S.	The Atlantic Telegraph.
	Rev. Dr. Livingstone, D.C.L. ...	Recent discoveries in Africa.
1858. Leeds.........	Prof. J. Phillips, LL.D., F.R.S.	The Ironstones of Yorkshire.
	Prof. R. Owen, M.D., F.R.S. ...	The Fossil Mammalia of Australia.
1859. Aberdeen ...	Sir R. I. Murchison, D.C.L.	Geology of the Northern Highlands.
	Rev. Dr. Robinson, F.R.S.	Electrical Discharges in highly rarefied Media.
1860. Oxford	Rev. Prof. Walker, F.R.S.	Physical Constitution of the Sun.
	Captain Sherard Osborn, R.N. .	Arctic Discovery.
1861. Manchester .	Prof. W. A. Miller, M.A., F.R.S.	Spectrum Analysis.
	G. B. Airy, F.R.S., Astron. Roy. .	The late Eclipse of the Sun.
1862. Cambridge .	Prof. Tyndall, LL.D., F.R.S. ...	The Forms and Action of Water.
	Prof. Odling, F.R.S................	Organic Chemistry.
1863. Newcastle-on-Tyne.	Prof. Williamson, F.R.S.	The chemistry of the Galvanic Battery considered in relation to Dynamics.
	James Glaisher, F.R.S.	The Balloon Ascents made for the British Association.
1864. Bath	Prof. Roscoe, F.R.S................	The Chemical Action of Light.
	Dr. Livingstone, F.R.S.	Recent Travels in Africa.

Date and Place.	Lecturer.	Subject of Discourse.
1865. Birmingham	J. Beete Jukes, F.R.S.	Probabilities as to the position and extent of the Coal-measures beneath the red rocks of the Midland Counties.
1866. Nottingham.	William Huggins, F.R.S..........	The results of Spectrum Analysis applied to Heavenly Bodies.
	Dr. J. D. Hooker, F.R.S..........	Insular Floras.
1867. Dundee......	Archibald Geikie, F.R.S..........	The Geological origin of the present Scenery of Scotland.
	Alexander Herschel, F.R.A.S. ...	The present state of knowledge regarding Meteors and Meteorites.
1868. Norwich	J. Fergusson, F.R.S.	Archæology of the early Buddhist Monuments.
	Dr. W. Odling, F.R.S.	Reverse Chemical Actions.
1869. Exeter	Prof. J. Phillips, LL.D., F.R.S.	Vesuvius.
	J. Norman Lockyer, F.R.S.......	The Physical Constitution of the Stars and Nebulæ.
1870. Liverpool ...	Prof. J. Tyndall, LL.D., F.R.S.	The Scientific Use of the Imagination.
	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	Stream-lines and Waves, in connexion with Naval Architecture.
1871. Edinburgh	F. A. Abel, F.R.S.	Some recent investigations and applications of Explosive Agents.
	E. B. Tylor, F.R.S.	The Relation of Primitive to Modern Civilization.
1872. Brighton ...	Prof. P. Martin Duncan, M.D., F.R.S.	Insect Metamorphosis.
	Prof. W. K. Clifford..............	The Aims and Instruments of Scientific Thought.
1873. Bradford ...	Prof. W. C. Williamson, F.R.S.	Coal and Coal Plants.
	Prof Clerk Maxwell F.R.S......	Molecules.
1874. Belfast......	Sir John Lubbock, Bart., M.P. F.R.S.	Common Wild Flowers considered in relation to Insects.
	Prof. Huxley, F.R.S.	The Hypothesis that Animals are Automata, and its History.

Lectures to the Operative Classes.

1867. Dundee......	Prof. J. Tyndall, LL.D., F.R.S.	Matter and Force.
1868. Norwich	Prof. Huxley, LL.D., F.R.S. ...	A piece of Chalk.
1869. Exeter	Prof. Miller, M.D., F.R.S.	Experimental illustrations of the modes of detecting the Composition of the Sun and other Heavenly Bodies by the Spectrum.
1870. Liverpool ...	Sir John Lubbock, Bart., M.P., F.R.S.	Savages.
1872. Brighton ...	William Spottiswoode, LL.D., F.R.S.	Sunshine, Sea, and Sky.
1873. Bradford ...	C. W. Siemens, D.C.L., F.R.S...	Fuel.
1874. Belfast......	Professor Odling, F.R.S...	The Discovery of Oxygen.

THE GENERAL TREASURER'S ACCOUNT from September 17, 1873 (commencement of BRADFORD Meeting) to August 19, 1874 (BELFAST).

RECEIPTS.

	£	s.	d.
To Balance brought from last Account	924	15	10
Received for Life Compositions at Bradford Meeting and since	358	0	0
" Annual Subscriptions, ditto ditto	646	0	0
" Associates' Tickets, ditto ditto	796	0	0
" Ladies' Tickets, ditto ditto	601	0	0
" Dividends on Stock	237	10	0
" for Sale of Publications	21	18	1
" Balance of Grant made at Brighton to the Sewage Committee	26	8	7
	3611	12	6
	£3611	12	6

Examined and found correct.

JOHN EVANS,
J. H. GLADSTONE,
JAMES J. SYLVESTER, } *Auditors.*

PAYMENTS.

	£	s.	d.	£	s.	d.
Paid Expenses of Bradford Meeting, also Sundry Printing, Binding, Advertising, and Incidental Petty Expenses				373	8	4
" Printing, Engraving, &c. Report of 42nd Meeting, Vol. XLI. (Brighton)				696	13	10
" Printing on account of Report of 43rd Meeting, Vol. XLII. (Bradford)				58	13	5
" Salaries, &c. (1 year)				462	6	0
" Rent and Office Expenses (Albemarle Street)				104	5	0
" Grants made at the Bradford Meeting, viz.—						
Zoological Record	100	0	0			
Chemistry Record	100	0	0			
Printing Mathematical Tables	100	0	0			
Committee on Elliptic Functions	100	0	0			
" Lightning Conductors	10	0	0			
" Thermal Conductivity of Rocks	10	0	0			
" Anthropological Instructions, &c.	50	0	0			
" Kent's Cavern Exploration	150	0	0			
" Luminous Meteors	30	0	0			
" Intestinal Secretions	15	0	0			
" British Rainfall	100	0	0			
" Essential Oils	10	0	0			
" Sub-Wealden Explorations	25	0	0			
" Settle Cave Exploration	50	0	0			
" Mauritius Meteorological Research	100	0	0			
" Magnetization of Iron	20	0	0			
" Marine Organisms	30	0	0			
" Fossils, North-west of Scotland	2	10	0			
" Physiological Action of Light	20	0	0			
" Trades Unions	25	0	0			
" Mountain-Limestone Corals	25	0	0			
" Erratic Blocks	10	0	0			
" Dredging, Durham and Yorkshire	28	5	0			
" High Temperature of Bodies	30	0	0			
" Siemens' Pyrometer	3	6	0			
" Labyrinthodont of Coal-Measures	7	15	0			
				1151	16	0
1874. " Widow of W. J. Askham				50	0	0
Aug. 19. Balance at London and Westminster Bank	£698	10	5			
" in hands of General Treasurer	15	19	6			
				714	9	11
				£3611	12	6

W. SPOTTISWOODE,
August 19, 1874.

Table showing the Attendance and Receipts

Date of Meeting.	Where held.	Presidents.	Old Life Members.	New Life Members.
1831, Sept. 27 ...	York	The Earl Fitzwilliam, D.C.L.	...	...
1832, June 19 ...	Oxford	The Rev. W. Buckland, F.R.S.	...	...
1833, June 25 ...	Cambridge	The Rev. A. Sedgwick, F.R.S.	...	...
1834, Sept. 8 ...	Edinburgh	Sir T. M. Brisbane, D.C.L.	...	...
1835, Aug. 10 ...	Dublin	The Rev. Provost Lloyd, LL.D.	...	...
1836, Aug. 22 ...	Bristol	The Marquis of Lansdowne	...	...
1837, Sept. 11 ...	Liverpool	The Earl of Burlington, F.R.S.	...	...
1838, Aug. 10 ...	Newcastle-on-Tyne	The Duke of Northumberland	...	...
1839, Aug. 26 ...	Birmingham	The Rev. W. Vernon Harcourt	...	...
1840, Sept. 17 ...	Glasgow	The Marquis of Breadalbane	...	...
1841, July 20 ...	Plymouth	The Rev. W. Whewell, F.R.S.	169	65
1842, June 23 ...	Manchester	The Lord Francis Egerton	303	169
1843, Aug. 17 ...	Cork	The Earl of Rosse, F.R.S.	109	28
1844, Sept. 26 ...	York	The Rev. G. Peacock, D.D.	226	150
1845, June 19 ...	Cambridge	Sir John F. W. Herschel, Bart.	313	36
1846, Sept. 10 ...	Southampton	Sir Roderick I. Murchison, Bart.	241	10
1847, June 23 ...	Oxford	Sir Robert H. Inglis, Bart.	314	18
1848, Aug. 9 ...	Swansea	The Marquis of Northampton	149	3
1849, Sept. 12 ...	Birmingham	The Rev. T. R. Robinson, D.D.	227	12
1850, July 21 ...	Edinburgh	Sir David Brewster, K.H.	235	9
1851, July 2 ...	Ipswich	G. B. Airy, Esq., Astron. Royal	172	8
1852, Sept. 1 ...	Belfast	Lieut.-General Sabine, F.R.S.	164	10
1853, Sept. 3 ...	Hull	William Hopkins, Esq., F.R.S.	141	13
1854, Sept. 20 ...	Liverpool	The Earl of Harrowby, F.R.S.	238	23
1855, Sept. 12 ...	Glasgow	The Duke of Argyll, F.R.S.	194	33
1856, Aug. 6 ...	Cheltenham	Prof. C. G. B. Daubeny, M.D.	182	14
1857, Aug. 26 ...	Dublin	The Rev. Humphrey Lloyd, D.D.	236	15
1858, Sept. 22 ...	Leeds	Richard Owen, M.D., D.C.L.	222	42
1859, Sept. 14 ...	Aberdeen	H.R.H. The Prince Consort	184	27
1860, June 27 ...	Oxford	The Lord Wrottesley, M.A.	286	21
1861, Sept. 4 ...	Manchester	William Fairbairn, LL.D., F.R.S.	321	113
1862, Oct. 1 ...	Cambridge	The Rev. Prof. Willis, M.A.	239	15
1863, Aug. 26 ...	Newcastle-on-Tyne	Sir William G. Armstrong, C.B.	203	36
1864, Sept. 13 ...	Bath	Sir Charles Lyell, Bart., M.A.	287	40
1865, Sept. 6 ...	Birmingham	Prof. J. Phillips, M.A., LL.D.	292	44
1866, Aug. 22 ...	Nottingham	William R. Grove, Q.C., F.R.S.	207	31
1867, Sept. 4 ...	Dundee	The Duke of Buccleuch, K.C.B.	167	25
1868, Aug. 19 ...	Norwich	Dr. Joseph D. Hooker, F.R.S.	196	18
1869, Aug. 18 ...	Exeter	Prof. G. G. Stokes, D.C.L.	204	21
1870, Sept. 14 ...	Liverpool	Prof. T. H. Huxley, LL.D.	314	39
1871, Aug. 2 ...	Edinburgh	Prof. Sir W. Thomson, LL.D.	246	28
1872, Aug. 14 ...	Brighton	Dr. W. B. Carpenter, F.R.S	245	36
1873, Sept. 17 ...	Bradford	Prof. A. W. Williamson, F.R.S.	212	27
1874, Aug. 19 ...	Belfast	Prof. J. Tyndall, LL.D, F.R.S.	162	13
1875, Aug. 25 ...	Bristol	Sir John Hawkshaw, C.E., F.R.S.		

at Annual Meetings of the Association.

Attended by						Amount received during the Meeting.	Sums paid on Account of Grants for Scientific Purposes.
Old Annual Members.	New Annual Members.	Associates.	Ladies.	Foreigners.	Total.		
						£ s. d.	£ s. d.
...	...	...	...	...	353	....	....
...	...	...	...	...	...	....	....
...	...	...	...	...	900	....	....
...	...	...	...	...	1298	....	20 0 0
...	...	...	...	...	...	....	167 0 0
...	...	...	...	...	1350	....	434 14 0
...	...	...	...	...	1840	....	918 14 6
...	...	...	1100*	...	2400	....	956 12 2
...	...	...	...	34	1438	....	1595 11 0
...	...	...	...	40	1353	....	1546 16 4
46	317	...	60*	...	891	....	1235 10 11
75	376	33†	331*	28	1315	....	1449 17 8
71	185	...	160	...	...	....	1565 10 2
45	190	9†	260	...	...	....	981 12 8
94	22	407	172	35	1079	....	830 9 9
65	39	270	196	36	857	....	685 16 0
197	40	495	203	53	1260	....	208 5 4
54	25	376	197	15	929	707 0 0	275 1 8
93	33	447	237	22	1071	963 0 0	159 19 6
128	42	510	273	44	1241	1085 0 0	345 18 0
61	47	244	141	37	710	620 0 0	391 9 7
63	60	510	292	9	1108	1085 0 0	304 6 7
56	57	367	236	6	876	903 0 0	205 0 0
121	121	765	524	10	1802	1882 0 0	330 19 7
142	101	1094	543	26	2133	2311 0 0	480 16 4
104	48	412	346	9	1115	1098 0 0	734 13 9
156	120	900	569	26	2022	2015 0 0	507 15 3
111	91	710	509	13	1698	1931 0 0	618 18 2
125	179	1206	821	22	2564	2782 0 0	684 11 1
177	59	636	463	47	1689	1604 0 0	1241 7 0
184	125	1589	791	15	3139	3944 0 0	1111 5 10
150	57	433	242	25	1161	1089 0 0	1293 16 6
154	209	1704	1004	25	3335	3640 0 0	1608 3 10
182	103	1119	1058	13	2802	2965 0 0	1289 15 8
215	149	766	508	23	1997	2227 0 0	1591 7 10
218	105	960	771	11	2303	2469 0 0	1750 13 4
193	118	1163	771	7	2444	2613 0 0	1739 4 0
226	117	720	682	45‡	2004	2042 0 0	1940 0 0
229	107	678	600	17	1856	1931 0 0	1572 0 0
303	195	1103	910	14	2878	3096 0 0	1472 2 6
311	127	976	754	21	2463	2575 0 0	1285 0 0
280	80	937	912	43	2533	2649 0 0	1685 0 0
237	99	796	601	11	1983	2102 0 0	1151 16 0
232	85	817	630	12	1951	1979 0 0	

* Ladies were not admitted by purchased Tickets until 1843.
† Tickets for admission to Sections only. ‡ Including Ladies.

OFFICERS OF SECTIONAL COMMITTEES PRESENT AT THE BELFAST MEETING.

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GENERAL TREASURER.

Professor A. W. WILLIAMSON, Ph.D., F.R.S., F.C.S., University College, London, W.C.

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Professor Sylvester, F.R.S.
J. Evans, Esq., F.R.S.
Dr. J. H. Gladstone, F.R.S.

Report of the Council for the Year 1873–74 *presented to the General Committee at Belfast, on Wednesday, August* 19*th*, 1874.

The Council have received Reports during the past year from the General Treasurer; and his Account for the year will be laid before the General Committee this day.

The General Committee at Bradford referred the following four Resolutions to the Council for their consideration, and they beg to report their proceedings upon each case:—

First Resolution.—"That the Council be requested to take steps to bring the importance of the meteorological researches at Mauritius before the Government, in order that, when they become convinced of the value of these researches by the action of the Association, they may be induced to increase the assistance."

The Council found that it was unnecessary to take action in this case, the application made by the Association last year having resulted in an increase to the Staff of the Observatory by the Government.

Second Resolution.—"That the Council be requested to take such steps as they may consider desirable for the purpose of representing to Her Majesty's Government the importance of the scientific results to be obtained from Arctic Exploration."

In November last, Sir Bartle Frere, President of the Royal Geographical Society, requested Mr. Gladstone to receive a joint deputation from the Royal Society, the Royal Geographical Society, the British Association, and the Dundee Chamber of Commerce, on the subject of an Arctic Expedition. Mr. Gladstone declined to receive a deputation, but requested an application, stating reasons, in a written form. This was furnished, but a change of Government occurred. Mr. Disraeli, since his accession to office, has received a deputation on the subject, consisting of Sir H. Rawlinson, Dr. Hooker, and Admiral Sherard Osborne, but no answer has yet been returned to their application.

Third Resolution.—"That the Council be requested to consider the possibility and expediency of making arrangements for the constitution of an Annual Museum for the exhibition of specimens and apparatus on a similar footing to that of the Sections, and similarly provided with officers to superintend the arrangements."

The Council, in accordance with the desire of the General Committee, have provided a room, and appointed a Committee, consisting of the General and Assistant General Secretaries, Professor Redfern, Mr. Ewart (one of the Local Secretaries), and Mr. Ray Lankester, to make the necessary arrangements for the reception and due exhibition of specimens and apparatus illustrative of Papers to be read at the Meeting.

Fourth Resolution.—"That the Council of the British Association be requested to communicate with the authorities in charge of the St. Gothard's Tunnel, with the view of obtaining permission for the Committee on Underground Temperature to take observations on temperature during the progress of the works."

Steps are being taken in pursuance of this Resolution.

The Council have had under their consideration the advisability of laying down some systematic rule to govern the election of Members of Council, and they recommend to the General Committee the adoption of the following regulations, which are in reality little more than a definite expression of the general practice of past years:—

(1) The Council shall consist of
   1. The Trustees.
   2. The past Presidents.
   3. The President and Vice-Presidents for the time being.
   4. The President and Vice-Presidents elect.
   5. The past and present General Treasurers, General and Assistant General Secretaries.
   6. The Local Treasurer and Secretaries for the ensuing Meeting.
   7. Ordinary Members.

(2) The Ordinary Members shall be elected annually from the General Committee.

(3) There shall be not more than twenty-five Ordinary Members, of whom not more than twenty shall have served on the Council, as Ordinary Members, in the previous year.

(4) In order to carry out the foregoing rule, the following Ordinary Members of the outgoing Council shall at each annual election be ineligible for nomination:—1st, those who have served on the Council for the greatest number of consecutive years; and, 2nd, those who, being resident in or near London, have attended the fewest number of Meetings during the year—observing (as nearly as possible) the proportion of three by seniority to two by least attendance.

(5) The Council shall submit to the General Committee in their Annual Report the names of the Members of General Committee whom they recommend for election as Members of Council.

(6) The Election shall take place at the same time as that of the Officers of the Association.

In order to assist the consideration of this question, the Council have appended to this Report a list of the Ordinary Members of Council, showing the date of election in each case.

The Council have added the following list of names of gentlemen present at the last Meeting of the Association to the list of Corresponding Members:—

Il Signor Guido Cora.
Dr. Felix Klein.
Baron von Richthofen, Berlin.
Dr. A. Shafarik, Prague.
Professor J. Lawrence Smith, Louisville, U. S.

In consequence of the Nomination to the Presidency of Section D of Professor Redfern, who was appointed Local Secretary by the General Committee at the last Meeting at Bradford, the Council have nominated Professor G. Fuller to be a Local Secretary.

The Council have to announce that Mr. W. Spottiswoode has notified to them that he is unable to continue to hold the office of General Treasurer. The Council have received this announcement with great regret, a regret which they feel will be shared by the Association. Mr. Spottiswoode has occupied the post of General Treasurer for the last thirteen years, and has invariably promoted the interests of the Association with untiring zeal and ability.

After much consideration, they have resolved to recommend Dr. A. Williamson as Treasurer in the place of Mr. W. Spottiswoode.

The General Committee will remember that Bristol has been selected as the place of Meeting for next year. The Council understand that an invitation to hold a subsequent Meeting at Glasgow will be presented to the General Committee.

The Council cannot close their Report without making some mention of the irreparable loss which the Association has sustained in the death of the late Professor Phillips.

He, in conjunction with Dean Buckland, Canon Vernon Harcourt, and others, founded the Association in 1831, and, from that time until his death, his labours on its behalf were untiring.

He acted as Local Secretary at the first Meeting at York; he filled, from the following year to the year 1862, the office of Assistant General Secretary; from 1862 to 1864 that of General Secretary; he was President in 1865; and, having seldom been absent from any of the Meetings, he presided last year at Bradford over the Geological Section.

In Professor Phillips, eminence in his own branch of Science and wide general culture, were united with unselfish sympathetic nature, a genial kindly manner and with a singularly happy tact in the conduct of affairs. It was this rare combination of qualities which guided the Association through its early difficulties to the success it has at present achieved, and which now makes his loss felt as one which can never be filled up.

Appendix.

Ordinary Members of the Council, and the Dates of their Election.

Elected.		Elected.	
1870.	Beddoe, John, M.D., F.R.S.	1873.	Maxwell, Prof. J. C., F.R.S.
1873.	Bramwell, F. J., Esq., C.E., F.R.S.	1871.	Merrifield, C. W., Esq., F.R.S.
1870.	Debus, Dr. H., F.R.S.	1870.	Northcote, Right Hon. Sir S. H.
1872.	De La Rue, W., Esq., D.C.L., F.R.S.	1873.	Ommanney, Adm. E., C.B., F.R.S.
1868.	Evans, John, Esq., F.R.S.	1873.	Pengelly, W., Esq., F.R.S.
1871.	Fitch, J. G., Esq., M.A.	1873.	Prestwich, J., Esq., F.R.S.
1872.	Flower, Prof. W. H., F.R.S.	1873.	Russell, Dr. W. J., F.R.S.
1871.	Foster, Prof. G. C., F.R.S.	1872.	Sclater, P. L., Esq., F.R.S.
1868.	Galton, Francis, Esq., F.R.S.	1871.	Siemens, C. W., Esq., F.R.S.
1871.	Hirst, Dr. T. Archer, F.R.S.	1873.	Smith, Prof. H. J. S., F.R.S.
1868.	Huggins, W., Esq., F.R.S.	1871.	Strachey, Major-General, F.R S.
1871.	Jeffreys, J. Gwyn, Esq., F.R.S.	1868.	Strange, Lieut.-Col. A., F.R.S.
1871.	Lockyer, J. N., Esq., F.R.S.		

Recommendations adopted by the General Committee at the Belfast Meeting in August 1874.

[When Committees are appointed, the Member first named is regarded as the Secretary, except there is a specific nomination.]

Involving Grants of Money.

That the Committee, consisting of Professor Cayley, Professor G. G. Stokes, Professor H. J. S. Smith, Professor Sir W. Thomson, and Mr. J. W. L. Glaisher (Secretary), on Mathematical Tables be reappointed, and that £100 be granted to them towards the printing the tables of the Elliptic Functions.

That the Committee on the Magnetization of Iron, Nickel, and Cobalt, consisting of Professor Balfour Stewart and Mr. W. F. Barrett, be reappointed, with the addition of Professor Clerk Maxwell, and that the sum of £20 be placed at their disposal.

That the Committee for reporting on the Rainfall of the British Isles, consisting of Mr. C. Brooke, Mr. J. Glaisher, Mr. J. F. Bateman, Mr. T. Hawksley, Mr. G. J. Symons, Mr. C. Tomlinson, and Mr. Rogers Field, be reappointed; that the Earl of Rosse and Mr. J. Smyth, Junior, be added to the Committee; that Mr. G. J. Symons be the Secretary; that £100 be granted for the ordinary purposes of the Committee, and £20 extra for observations in the watershed of the Shannon, and in other parts of Ireland, respecting the rainfall of which no records exist.

That the Committee, consisting of Mr. James Glaisher, Mr. R. P. Greg Mr. Charles Brooke, Professor G. Forbes, and Professor A. S. Herschel, on Luminous Meteors, be reappointed, and that the sum of £30 be placed at their disposal for the purpose of providing a sufficient supply of maps and registers for their observations.

That Professor Clerk Maxwell, Professor J. D. Everett, and Mr. A. Schuster be appointed a Committee for the purpose of testing experimentally the exactness of Ohm's law; that Mr. Schuster be the Secretary, and that the sum of £50 be placed at their disposal for the purpose.

That a Committee, consisting of Professor Stokes, Dr. De La Rue, Professor Clerk Maxwell, Mr. W. F. Barrett, Mr. Howard Grubb, and Mr. G. Johnstone Stoney, be appointed to examine and report upon the reflective powers of silver, gold, and platinum, whether in mass or chemically deposited on glass, and of speculum metal, and that the sum of £20 be placed at their disposal.

That the Committee, consisting of Professor A. S. Herschel and Mr. G. A. Lebour, for making experiments on the Thermal Conductivities of certain rocks, be reappointed; that Professor A. S. Herschel be the Secretary, and that £10 be placed at their disposal for the purpose.

That the Committee on Thermo-Electricity, consisting of Professor Tait, Professor Tyndall, and Professor Balfour Stewart, be reappointed, and that the grant of £50 which has lapsed be renewed.

That Professors Williamson, Frankland, and Roscoe be a Committee for the purpose of superintending the publication by the Chemical Society of the Monthly Reports on the Progress of Chemistry; that Professor Williamson be the Secretary, and that the sum of £100 be placed at their disposal for the purpose.

That Professors Roscoe, Balfour Stewart, and Thorpe be a Committee for the purpose of determining the Specific Volumes of Liquids; that Dr. Thorpe

be the Secretary, and that the sum of £25 be placed at their disposal for the purpose.

That Messrs. Allen, Dewar, Stanford, and Fletcher be a Committee for the purpose of examining and reporting upon the methods employed in the estimation of Potash and Phosphoric Acid in commercial products, and on the mode of stating the results; that Mr. A. H. Allen be the Secretary, and that the sum of £10 be placed at their disposal for the purpose.

That Dr. Armstrong and Professor Thorpe be a Committee for the purpose of investigating Isomeric Cresols and their derivatives; that Dr. Armstrong be the Secretary, and that the sum of £20 be placed at their disposal for the purpose.

That Mr. H. Willett, Mr. R. A. C. Godwin-Austen, Mr. W. Topley, Mr. Davidson, Professor Prestwich, Professor Boyd Dawkins, and Mr. Henry Woodward be a Committee for the purpose of promoting the "Sub-Wealden Exploration;" that Mr. H. Willett be the Secretary, and that the sum of £100 be placed at their disposal for the purpose.

That Sir C. Lyell, Bart., Sir J. Lubbock, Bart., Mr. J. Evans, Mr. E. Vivian, Mr. W. Pengelly, Mr. G. Busk, Mr. Boyd Dawkins, Mr. W. A. Sanford, and Mr. J. E. Lee be a Committee for the purpose of continuing the exploration of Kent's Cavern, Torquay; that Mr. Pengelly be the Secretary, and that the sum of £100 be placed at their disposal for the purpose.

That Sir John Lubbock, Bart., Mr. Boyd Dawkins, Rev. H. W. Crosskey, Professor Hughes, Mr. L. C. Miall, Professor Prestwich, and Mr. R. H. Tiddeman be a Committee for the purpose of assisting the exploration of the Victoria Cave, Settle; that Mr. Tiddeman be the Secretary, and that the sum of £50 be placed at their disposal for the purpose.

That Dr. Bryce, Mr. J. Brough, Mr. G. Forbes, Mr. D. Milne-Holme, Mr. J. Thomson, and Professor Sir W. Thomson be a Committee for the purpose of continuing the Observations and Records of Earthquakes in Scotland; that Dr. Bryce be the Secretary, and that the sum of £20 be placed at their disposal for the purpose.

That Professor Hull, Mr. E. W. Binney, Mr. F. J. Bramwell, Rev. H. W. Crosskey, Professor A. H. Green, Professor Harkness, Mr. W. Molyneux, Mr. G. H. Morton, Mr. R. W. Mylne, Mr. Pengelly, Professor Prestwich, Mr. James Plant, Mr. De Rance, Rev. W. S. Symonds, and Mr. W. Whitaker be a Committee for the purpose of investigating the circulation of the underground waters in the New Red Sandstone and Permian formations of England, and the quantity and character of the water supplied to various towns and districts from those formations; that Mr. De Rance be the Secretary, and that the sum of £10 be placed at their disposal for the purpose.

That Mr. Dresser, Viscount Walden, Mr. R. B. Sharpe, Mr. O. Salvin, and Mr. Sclater be a Committee for the purpose of preparing a Report on the present state of our knowledge of the Ornithology of the various parts of the world; that Mr. Sclater be the Secretary, and that the sum of £10 be placed at their disposal for the purpose of preliminary printing.

That Professor Rolleston, Mr. Ray Lankester, and Mr. Balfour be a Committee for the purpose of investigating the early stages of the development of the Myxinoid Fishes; that Mr. Lankester be the Secretary, and that the sum of £20 be placed at their disposal for the purpose.

That Mr. Stainton, Sir John Lubbock, and Professor Newton be a Committee for the purpose of continuing a Record of Zoological Literature; that Mr. Stainton be the Secretary, and that the sum of £100 be placed at their disposal for the purpose.

That Colonel Lane Fox, Dr. Beddoe, Mr. Franks, Mr. F. Galton, Mr. E. W. Brabrook, Sir J. Lubbock, Sir Walter Elliot, Mr. C. R. Markham, Mr. E. B. Tylor, Mr. J. Evans, and Mr. F. W. Rudler be reappointed a Committee for the purpose of preparing and publishing brief forms of instruction for travellers, ethnologists, and other anthropological observers; that Colonel Lane Fox be the Secretary, and that the sum of £20 be placed at their disposal for the purpose.

That Dr. Brunton and Dr. Pye-Smith be a Committee for the purpose of investigating the nature of Intestinal Secretion; that Dr. Brunton be the Secretary, and that the sum of £20 be placed at their disposal for the purpose.

That Major Wilson and Mr. Ravenstein be a Committee for the purpose of furthering the Palestine explorations; and that the sum of £100 be placed at their disposal, to be expended on behalf of the Topographical Survey, and especially in ascertaining the level of the Sea of Galilee and the fall of the river Jordan.

That the Committee, consisting of Lord Houghton, Professor Thorold Rogers, W. Newmarch, Professor Fawcett, M.P., Jacob Behrens, F. P. Fellows, R. H. Inglis Palgrave, Archibald Hamilton, and S. Brown, on Capital and Labour, be reappointed; that Professor Leone Levi be the Secretary, and that the sum of £25 be placed at their disposal for the purpose.

That the Committee on instruments for measuring the speed of ships be reappointed; that it consist of the following Members:—Mr. W. Froude, Mr. F. J. Bramwell, Mr. A. E. Fletcher, Rev. E. L. Berthon, Mr. James R. Napier, Mr. C. W. Merrifield, Dr. C. W. Siemens, Mr. H. M. Brunel, Mr. W. Smith, Sir William Thomson, and Mr. J. N. Shoolbred; that Professor James Thomson be added to the Committee; that Mr. J. N. Shoolbred be the Secretary, and that the sum of £50 be placed at their disposal for the purpose.

Applications for Reports and Researches not involving Grants of Money.

That the Committee, consisting of Dr. Huggins, Dr. De La Rue, Mr. J. N. Lockyer, Dr. Reynolds, Mr. Spottiswoode, Mr. G. J. Stoney, and Mr. W. M. Watts, on Wave Numbers be reappointed.

That Mr. Spottiswoode, Professor Stokes, Professor Cayley, Professor Clifford, and Mr. J. W. L. Glaisher be appointed a Committee to report on Mathematical Notation and printing, with the view of leading mathematicians to prefer in optional cases such forms as are more easily put into type, and of promoting uniformity of notation.

That Mr. W. H. L. Russell be requested to continue his Report on recent progress in the Theory of Elliptic and Hyperelliptic Functions.

That the Committee on Underground Temperature, consisting of Professor Everett (Secretary), Professor Sir W. Thomson, Sir Charles Lyell, Bart., Professor J. Clerk Maxwell, Mr. G. J. Symons, Professor Ramsay, Professor Geikie, Mr. J. Glaisher, Rev. Dr. Graham, Mr. George Maw, Mr. Pengelly, Mr. S. J. Mackie, Professor Edward Hull, Professor Ansted, and Dr. Clement Le Neve Foster, be reappointed.

That the Committee on Teaching Physics in Schools be reappointed, with the addition of the names of Professor J. Clerk Maxwell, Mr. J. Perry, and Mr. G. F. Rodwell.

That the Committee on Tides, consisting of Professor Sir W. Thomson, Professor J. C. Adams, Mr. J. Oldham, Rear-Admiral Richards, General Strachey, Mr. W. Parkes, Mr. Webster, and Colonel Walker, be reappointed.

That the Committee, consisting of Professor Cayley, Mr. J. W. L. Glaisher, Dr. W. Pole, Mr. Merrifield, Professor Fuller, Mr. H. M. Brunel, and Professor W. K. Clifford, be reappointed to estimate the cost of constructing Mr. Babbage's Analytical Engine, and to consider the advisability of printing tables by its means.

That the Committee, consisting of Dr. Joule, Professor Sir W. Thomson, Professor Tait, Professor Balfour Stewart, and Professor J. Clerk Maxwell, be reappointed to effect the determination of the Mechanical Equivalent of Heat.

That Professor Sylvester, Professor Cayley, Professor Hirst, Rev. Professor Bartholomew Price, Professor H. J. S. Smith, Dr. Spottiswoode, Mr. R. B. Hayward, Dr. Salmon, Rev. R. Townsend, Professor Fuller, Professor Kelland, Mr. J. M. Wilson, and Professor Clifford be reappointed a Committee (with power to add to their number) for the purpose of considering the possibility of improving the methods of instruction in elementary geometry; and that Professor Clifford be the Secretary.

That Professors Williamson, Roscoe, and Gladstone, Dr. Carpenter, Sir Walter Elliot, and Mr. Lockyer be a Committee for the purpose of reporting on Science-Lectures; that Professor Roscoe be the Secretary.

That Dr. Mills, Dr. Boycott, Mr. Gadesden, Mr. Sellon, and Mr. W. Chandler Roberts be a Committee for the purpose of investigating the methods of making gold assays, and stating the results thereof; that Mr. W. Chandler Roberts be the Secretary.

That Messrs. H. B. Grantham, Bramwell, and W. Hope, Professor Corfield, Dr. J. H. Gilbert, and Professor Williamson be a Committee for the purpose of continuing the investigations on the Treatment and Utilization of Sewage.

That Professor Harkness, Mr. Prestwich, Professor Hughes, Rev. H. W. Crosskey, Messrs. Woodward, Dawkins, Maw, Miall, Morton, Lee, Pengelly, Plant, and Tiddeman be a Committee for the purpose of recording the position, height above the sea, lithological characters, size, and origin of the more important of the Erratic Blocks of England and Wales, reporting other matters of interest connected with the same, and taking measures for their preservation; that the Rev. H. W. Crosskey be the Secretary.

That Professor Huxley, Mr. Sclater, Mr. F. M. Balfour, Mr. Gwyn Jeffreys, Dr. M. Foster, Mr. Ray Lankester, and Mr. Dew Smith be a Committee for the purpose of making a report on the Zoological Station at Naples, and that Mr. Dew Smith be the Secretary.

That the Rev. H. F. Barnes, Mr. Dresser, Mr. Harland, Mr. Harting, Professor Newton, and the Rev. Canon Tristram be reappointed a Committee for the purpose of considering the desirability of establishing "a close time" for the protection of indigenous animals, and for watching Bills introduced into Parliament affecting this subject, and that Mr. Dresser be the Secretary.

That Mr. Spence Bate be requested to draw up a Report on the present state of our knowledge of the Crustacea.

That the Metric Committee be reappointed, consisting of James Heywood, M.A., F.R.S., Lord O'Hagan, The Right Hon. Sir Stafford Northcote, K.C.B., M.P., Sir W. Armstrong, F.R.S., Samuel Brown, F.S.S., William Farr, M.D., D.C.L., F.R.S., Frank P. Fellows, F.S.S., Archibald Hamilton, F.S.S., Professor Frankland, F.R.S., Professor Hennessy, F.R.S., Professor Leone Levi, F.S.S., C. W. Siemens, F.R.S., Professor A. W. Williamson, F.R.S., Major-General Strachey, F.R.S., and Dr. Roberts, and that Samuel Brown, F.S.S., be the Secretary.

That Mr. W. H. Barlow, Mr. H. Bessemer, Mr. F. J. Bramwell, Captain

Douglas Galton, Sir John Hawkshaw, Dr. C. W. Siemens, Professor Abel, and Mr. E. H. Carbutt be a Committee for the purpose of considering what steps can be taken in furtherance of the use of steel for structural purposes, and that Mr. E. H. Carbutt be the Secretary.

That Mr. F. J. Bramwell, Mr. J. R. Napier, Mr. C. W. Merrifield, Sir John Hawkshaw, Mr. T. Webster, Q.C., and Professor Osborne Reynolds be a Committee for the purpose of considering and reporting upon British Measures in use for mechanical and other purposes.

That Mr. F. J. Bramwell, Mr. Hawksley, Mr. Edward Easton, Sir William Armstrong, and Mr. W. Hope be a Committee for the purpose of investigating and reporting upon the utilization and transmission of wind and water power, and that Mr. W. Hope be the Secretary.

Communications ordered to be printed in extenso *in the Annual Report of the Association.*

That Mr. Bentham's Report "On the recent progress and present state of systematic Botany, in connexion with the development of the Natural Method and the doctrine of Evolution" be printed *in extenso* among the Reports.

That the lists appended to Mr. Gwyn Jeffreys's paper in Section D, entitled "Additions to the British Mollusca and Notices of rare species from deep water off the western coasts of Ireland," be printed in full.

That Mr. Froude's "Report on the resistance of a full-sized ship" be printed in the Reports of the Association, together with the necessary Plates.

That Mr. Froude's paper "On Surface-friction in Water" (being a continuation of the Report on this subject presented at the Brighton Meeting) be printed *in extenso* in the Report, with the necessary Plates.

That Mr. J. Smyth's, Jun., M.A., C.E., F.C.S., paper "On the Industrial uses of the Upper Bann River" be printed *in extenso* in the Reports of the Association.

That Mr. T. R. Salmond's paper "On the Belfast Harbour" be printed *in extenso* in the Reports of the Association, together with the necessary plans.

Resolutions referred to the Council for consideration and action if it seem desirable.

That the Council be requested to take such steps as they may deem expedient to urge upon the Government of India the desirableness of continuing solar observations in India.

That the Council of the Association be requested to take such steps as they may think desirable with a view to promote the appointment of naturalists to vessels engaged on the coasts of little-known parts of the world.

That the Council be requested to take such steps as they may think desirable with the view of promoting any application that may be made to Her Majesty's Government by the Royal Society for a systematic Physical and Biological exploration of the seas around the British Isles.

That the Council should take such steps as they may think desirable for supporting the request to Her Majesty's Government to undertake an Arctic Expedition on the basis proposed by the Council of the Royal Geographical Society at the beginning of the present year, which it is understood will be again made by that body.

Synopsis of Grants of Money appropriated to Scientific Purposes by the General Committee at the Belfast Meeting in August 1874. *The names of the Members who would be entitled to call on the General Treasurer for the respective Grants are prefixed.*

Mathematics and Physics.

*Cayley, Professor.—Printing Mathematical Tables	£100	0	0
*Balfour Stewart, Professor.—Magnetization of Iron	20	0	0
*Brooke, Mr.—British Rainfall	120	0	0
*Glaisher, Mr. J.—Luminous Meteors	30	0	0
Maxwell, Professor C.—Testing the Exactness of Ohm's Law	50	0	0
Stokes, Professor.—Reflective Power of Silver and other Substances	20	0	0
*Herschel, Professor.—Thermal Conducting-power of Rocks	10	0	0
*Tait, Professor.—Thermo-Electricity (renewed)	50	0	0

Chemistry.

*Williamson, Professor A. W.—Records of the Progress of Chemistry	100	0	0
Roscoe, Professor.—Specific Volumes of Liquids	25	0	0
Allen, Mr.—Estimation of Potash and Phosphoric Acid	10	0	0
*Armstrong, Dr.—Isomeric Cresols and their Derivatives (renewed)	20	0	0

Geology.

*Willett, Mr. H.—The Sub-Wealden Exploration	100	0	0
*Lyell, Sir C., Bart.—Kent's Cavern Exploration	100	0	0
*Lubbock, Sir J.—Exploration of Victoria Cave, Settle	50	0	0
*Bryce, Dr.—Earthquakes in Scotland (renewed)	20	0	0
Hull, Professor.—Underground Waters in New Red Sand-Stone and Permian	10	0	0

Biology.

Dresser, Mr.—Report on Ornithology	10	0	0
Rolleston, Professor.—Development of Myxinoid Fishes	20	0	0
*Stainton, Mr.—Record of the Progress of Zoology	100	0	0
*Fox, Col. Lane.—Forms of Instruction for Travellers	20	0	0
*Brunton, Dr.—The Nature of Intestinal Secretion	20	0	0
Carried forward	£1005	0	0

* Reappointed.

Geography.

	£	s.	d.
Brought forward	£1005	0	0
Wilson, Major.—Palestine Exploration Fund	100	0	0

Statistics and Economic Science.

*Houghton, Lord.—Economic Effect of Combinations of Labourers, or Capitalists	25	0	0

Mechanics.

*Froude, Mr. W.—Instruments for Measuring the Speed of Ships and Currents (renewed)	50	0	0
Total	£1080	0	0

* Reappointed.

The Annual Meeting in 1875.

The Meeting at Bristol will commence on Wednesday, August 25, 1875.

Place of Meeting in 1876.

The Annual Meeting of the Association in 1876 will be held at Glasgow.

General Statement of Sums which have been paid on Account of Grants for Scientific Purposes.

	£	s.	d.
1834.			
Tide Discussions	20	0	0
1835.			
Tide Discussions	62	0	0
British Fossil Ichthyology	105	0	0
	£167	0	0
1836.			
Tide Discussions	163	0	0
British Fossil Ichthyology	105	0	0
Thermometric Observations, &c.	50	0	0
Experiments on long-continued Heat	17	1	0
Rain-Gauges	9	13	0
Refraction Experiments	15	0	0
Lunar Nutation	60	0	0
Thermometers	15	6	0
	£434	14	0
1837.			
Tide Discussions	284	1	0
Chemical Constants	24	13	6
Lunar Nutation	70	0	0
Observations on Waves	100	12	0
Tides at Bristol	150	0	0
Meteorology and Subterranean Temperature	89	5	0
Vitrification Experiments	150	0	0
Heart Experiments	8	4	6
Barometric Observations	30	0	0
Barometers	11	18	6
	£918	14	6
1838.			
Tide Discussions	29	0	0
British Fossil Fishes	100	0	0
Meteorological Observations and Anemometer (construction)	100	0	0
Cast Iron (Strength of)	60	0	0
Animal and Vegetable Substances (Preservation of)	19	1	10
Railway Constants	41	12	10
Bristol Tides	50	0	0
Growth of Plants	75	0	0
Mud in Rivers	3	6	6
Education Committee	50	0	0
Heart Experiments	5	3	0
Land and Sea Level	267	8	7
Subterranean Temperature	8	6	0
Steam-vessels	100	0	0
Meteorological Committee	31	9	5
Thermometers	16	4	0
	£956	12	2
1839.			
Fossil Ichthyology	110	0	0
Meteorological Observations at Plymouth	63	10	0
Mechanism of Waves	144	2	0
Bristol Tides	35	18	6
Meteorology and Subterranean Temperature	21	11	0
Vitrification Experiments	9	4	7
Cast-Iron Experiments	100	0	0
Railway Constants	28	7	2
Land and Sea Level	274	1	4
Steam-vessels' Engines	100	0	0
Stars in Histoire Céleste	331	18	6
Stars in Lacaille	11	0	0
Stars in R.A.S. Catalogue	6	16	6
Animal Secretions	10	10	0
Steam-engines in Cornwall	50	0	0
Atmospheric Air	16	1	0
Cast and Wrought Iron	40	0	0
Heat on Organic Bodies	3	0	0
Gases on Solar Spectrum	22	0	0
Hourly Meteorological Observations, Inverness and Kingussie	49	7	8
Fossil Reptiles	118	2	9
Mining Statistics	50	0	0
	£1595	11	0
1840.			
Bristol Tides	100	0	0
Subterranean Temperature	13	13	6
Heart Experiments	18	19	0
Lungs Experiments	8	13	0
Tide Discussions	50	0	0
Land and Sea Level	6	11	1
Stars (Histoire Céleste)	242	10	0
Stars (Lacaille)	4	15	0
Stars (Catalogue)	264	0	0
Atmospheric Air	15	15	0
Water on Iron	10	0	0
Heat on Organic Bodies	7	0	0
Meteorological Observations	52	17	6
Foreign Scientific Memoirs	112	1	6
Working Population	100	0	0
School Statistics	50	0	0
Forms of Vessels	184	7	0
Chemical and Electrical Phenomena	40	0	0
Meteorological Observations at Plymouth	80	0	0
Magnetical Observations	185	13	9
	£1546	16	4
1841.			
Observations on Waves	30	0	0
Meteorology and Subterranean Temperature	8	8	0
Actinometers	10	0	0
Earthquake Shocks	17	7	0
Acrid Poisons	6	0	0
Veins and Absorbents	3	0	0
Mud in Rivers	5	0	0
Marine Zoology	15	12	0
Skeleton Maps	20	0	8
Mountain Barometers	6	18	6
Stars (Histoire Céleste)	185	0	0

	£	s.	d.
Stars (Lacaille)	79	5	0
Stars (Nomenclature of)	17	19	6
Stars (Catalogue of)	40	0	0
Water on Iron	50	0	0
Meteorological Observations at Inverness	20	0	0
Meteorological Observations (reduction of)	25	0	0
Fossil Reptiles	50	0	0
Foreign Memoirs	62	0	0
Railway Sections	38	1	6
Forms of Vessels	193	12	0
Meteorological Observations at Plymouth	55	0	0
Magnetical Observations	61	18	8
Fishes of the Old Red Sandstone	100	0	0
Tides at Leith	50	0	0
Anemometer at Edinburgh	69	1	10
Tabulating Observations	9	6	3
Races of Men	5	0	0
Radiate Animals	2	0	0
	£1235	10	11

1842.

	£	s.	d.
Dynamometric Instruments	113	11	2
Anoplura Britanniæ	52	12	0
Tides at Bristol	59	8	0
Gases on Light	30	14	7
Chronometers	26	17	6
Marine Zoology	1	5	0
British Fossil Mammalia	100	0	0
Statistics of Education	20	0	0
Marine Steam-vessels' Engines	28	0	0
Stars (Histoire Céleste)	59	0	0
Stars (Brit. Assoc. Cat. of)	110	0	0
Railway Sections	161	10	0
British Belemnites	50	0	0
Fossil Reptiles (publication of Report)	210	0	0
Forms of Vessels	180	0	0
Galvanic Experiments on Rocks	5	8	6
Meteorological Experiments at Plymouth	68	0	0
Constant Indicator and Dynamometric Instruments	90	0	0
Force of Wind	10	0	0
Light on Growth of Seeds	8	0	0
Vital Statistics	50	0	0
Vegetative Power of Seeds	8	1	11
Questions on Human Race	7	9	0
	£1449	17	8

1843.

	£	s.	d.
Revision of the Nomenclature of Stars	2	0	0
Reduction of Stars, British Association Catalogue	25	0	0
Anomalous Tides, Frith of Forth	120	0	0
Hourly Meteorological Observations at Kingussie and Inverness	77	12	8
Meteorological Observations at Plymouth	55	0	0
Whewell's Meteorological Anemometer at Plymouth	10	0	0
Meteorological Observations, Osler's Anemometer at Plymouth	20	0	0
Reduction of Meteorological Observations	30	0	0
Meteorological Instruments and Gratuities	39	6	0
Construction of Anemometer at Inverness	56	12	2
Magnetic Cooperation	10	8	10
Meteorological Recorder for Kew Observatory	50	0	0
Action of Gases on Light	18	16	1
Establishment at Kew Observatory, Wages, Repairs, Furniture and Sundries	133	4	7
Experiments by Captive Balloons	81	8	0
Oxidation of the Rails of Railways	20	0	0
Publication of Report on Fossil Reptiles	40	0	0
Coloured Drawings of Railway Sections	147	18	3
Registration of Earthquake Shocks	30	0	0
Report on Zoological Nomenclature	10	0	0
Uncovering Lower Red Sandstone near Manchester	4	4	6
Vegetative Power of Seeds	5	3	8
Marine Testacea (Habits of)	10	0	0
Marine Zoology	10	0	0
Marine Zoology	2	14	11
Preparation of Report on British Fossil Mammalia	100	0	0
Physiological Operations of Medicinal Agents	20	0	0
Vital Statistics	36	5	8
Additional Experiments on the Forms of Vessels	70	0	0
Additional Experiments on the Forms of Vessels	100	0	0
Reduction of Experiments on the Forms of Vessels	100	0	0
Morin's Instrument and Constant Indicator	69	14	10
Experiments on the Strength of Materials	60	0	0
	£1565	10	2

1844.

	£	s.	d.
Meteorological Observations at Kingussie and Inverness	12	0	0
Completing Observations at Plymouth	35	0	0
Magnetic and Meteorological Cooperation	25	8	4
Publication of the British Association Catalogue of Stars	35	0	0
Observations on Tides on the East coast of Scotland	100	0	0
Revision of the Nomenclature of Stars 1842	2	9	6
Maintaining the Establishment in Kew Observatory	117	17	3
Instruments for Kew Observatory	56	7	3

	£	s.	d.
Influence of Light on Plants	10	0	0
Subterraneous Temperature in Ireland	5	0	0
Coloured Drawings of Railway Sections	15	17	6
Investigation of Fossil Fishes of the Lower Tertiary Strata	100	0	0
Registering the Shocks of Earthquakes 1842	23	11	10
Structure of Fossil Shells	20	0	0
Radiata and Mollusca of the Ægean and Red Seas......1842	100	0	0
Geographical Distributions of Marine Zoology 1842	10	0	0
Marine Zoology of Devon and Cornwall	10	0	0
Marine Zoology of Corfu	10	0	0
Experiments on the Vitality of Seeds	9	0	3
Experiments on the Vitality of Seeds 1842	8	7	3
Exotic Anoplura	15	0	0
Strength of Materials	100	0	0
Completing Experiments on the Forms of Ships	100	0	0
Inquiries into Asphyxia	10	0	0
Investigations on the Internal Constitution of Metals	50	0	0
Constant Indicator and Morin's Instrument 1842	10	3	6
	£981	12	8

1845.

	£	s.	d.
Publication of the British Association Catalogue of Stars	351	14	6
Meteorological Observations at Inverness	30	18	11
Magnetic and Meteorological Co-operation	16	16	8
Meteorological Instruments at Edinburgh	18	11	9
Reduction of Anemometrical Observations at Plymouth	25	0	0
Electrical Experiments at Kew Observatory	43	17	8
Maintaining the Establishment in Kew Observatory	149	15	0
For Kreil's Barometrograph	25	0	0
Gases from Iron Furnaces	50	0	0
The Actinograph	15	0	0
Microscopic Structure of Shells	20	0	0
Exotic Anoplura 1843	10	0	0
Vitality of Seeds 1843	2	0	7
Vitality of Seeds 1844	7	0	0
Marine Zoology of Cornwall	10	0	0
Physiological Action of Medicines	20	0	0
Statistics of Sickness and Mortality in York	20	0	0
Earthquake Shocks 1843	15	14	8
	£830	9	9

1846.

	£	s.	d.
British Association Catalogue of Stars 1844	211	15	0
Fossil Fishes of the London Clay	100	0	0
Computation of the Gaussian Constants for 1829	50	0	0
Maintaining the Establishment at Kew Observatory	146	16	7
Strength of Materials	60	0	0
Researches in Asphyxia	6	16	2
Examination of Fossil Shells	10	0	0
Vitality of Seeds 1844	2	15	10
Vitality of Seeds 1845	7	12	3
Marine Zoology of Cornwall	10	0	0
Marine Zoology of Britain	10	0	0
Exotic Anoplura 1844	25	0	0
Expenses attending Anemometers	11	7	6
Anemometers' Repairs	2	3	6
Atmospheric Waves	3	3	3
Captive Balloons 1844	8	19	3
Varieties of the Human Race 1844	7	6	3
Statistics of Sickness and Mortality in York	12	0	0
	£685	16	0

1847.

	£	s.	d.
Computation of the Gaussian Constants for 1829	50	0	0
Habits of Marine Animals	10	0	0
Physiological Action of Medicines	20	0	0
Marine Zoology of Cornwall	10	0	0
Atmospheric Waves	6	9	3
Vitality of Seeds	4	7	7
Maintaining the Establishment at Kew Observatory	107	8	6
	£208	5	4

1848.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	171	15	11
Atmospheric Waves	3	10	9
Vitality of Seeds	9	15	0
Completion of Catalogues of Stars	70	0	0
On Colouring Matters	5	0	0
On Growth of Plants	15	0	0
	£275	1	8

1849.

	£	s.	d.
Electrical Observations at Kew Observatory	50	0	0
Maintaining Establishment at ditto	76	2	5
Vitality of Seeds	5	8	1
On Growth of Plants	5	0	0
Registration of Periodical Phenomena	10	0	0
Bill on account of Anemometrical Observations	13	9	0
	£159	19	6

1850.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	255	18	0
Transit of Earthquake Waves	50	0	0
Periodical Phenomena	15	0	0
Meteorological Instruments, Azores	25	0	0
	£345	18	0

	£	s.	d.
1851.			
Maintaining the Establishment at Kew Observatory (includes part of grant in 1849)	309	2	2
Theory of Heat	20	1	1
Periodical Phenomena of Animals and Plants	5	0	0
Vitality of Seeds	5	6	4
Influence of Solar Radiation	30	0	0
Ethnological Inquiries	12	0	0
Researches on Annelida	10	0	0
	£391	9	7
1852.			
Maintaining the Establishment at Kew Observatory (including balance of grant for 1850)	233	17	8
Experiments on the Conduction of Heat	5	2	9
Influence of Solar Radiations	20	0	0
Geological Map of Ireland	15	0	0
Researches on the British Annelida	10	0	0
Vitality of Seeds	10	6	2
Strength of Boiler Plates	10	0	0
	£304	6	7
1853.			
Maintaining the Establishment at Kew Observatory	165	0	0
Experiments on the Influence of Solar Radiation	15	0	0
Researches on the British Annelida	10	0	0
Dredging on the East Coast of Scotland	10	0	0
Ethnological Queries	5	0	0
	£205	0	0
1854.			
Maintaining the Establishment at Kew Observatory (including balance of former grant)	330	15	4
Investigations on Flax	11	0	0
Effects of Temperature on Wrought Iron	10	0	0
Registration of Periodical Phenomena	10	0	0
British Annelida	10	0	0
Vitality of Seeds	5	2	3
Conduction of Heat	4	2	0
	£380	19	7
1855.			
Maintaining the Establishment at Kew Observatory	425	0	0
Earthquake Movements	10	0	0
Physical Aspect of the Moon	11	8	5
Vitality of Seeds	10	7	11
Map of the World	15	0	0
Ethnological Queries	5	0	0
Dredging near Belfast	4	0	0
	£480	16	4
1856.			
Maintaining the Establishment at Kew Observatory:— 1854......£ 75 0 0; 1855......£500 0 0	575	0	0
Strickland's Ornithological Synonyms	100	0	0
Dredging and Dredging Forms	9	13	9
Chemical Action of Light	20	0	0
Strength of Iron Plates	10	0	0
Registration of Periodical Phenomena	10	0	0
Propagation of Salmon	10	0	0
	£734	13	9
1857.			
Maintaining the Establishment at Kew Observatory	350	0	0
Earthquake Wave Experiments	40	0	0
Dredging near Belfast	10	0	0
Dredging on the West Coast of Scotland	10	0	0
Investigations into the Mollusca of California	10	0	0
Experiments on Flax	5	0	0
Natural History of Madagascar	20	0	0
Researches on British Annelida	25	0	0
Report on Natural Products imported into Liverpool	10	0	0
Artificial Propagation of Salmon	10	0	0
Temperature of Mines	7	8	0
Thermometers for Subterranean Observations	5	7	4
Life-Boats	5	0	0
	£507	15	4
1858.			
Maintaining the Establishment at Kew Observatory	500	0	0
Earthquake Wave Experiments	25	0	0
Dredging on the West Coast of Scotland	10	0	0
Dredging near Dublin	5	0	0
Vitality of Seeds	5	5	0
Dredging near Belfast	18	13	2
Report on the British Annelida	25	0	0
Experiments on the production of Heat by Motion in Fluids	20	0	0
Report on the Natural Products imported into Scotland	10	0	0
	£618	18	2
1859.			
Maintaining the Establishment at Kew Observatory	500	0	0
Dredging near Dublin	15	0	0
Osteology of Birds	50	0	0
Irish Tunicata	5	0	0
Manure Experiments	20	0	0
British Medusidæ	5	0	0
Dredging Committee	5	0	0
Steam-vessels' Performance	5	0	0
Marine Fauna of South and West of Ireland	10	0	0
Photographic Chemistry	10	0	0
Lanarkshire Fossils	20	0	1
Balloon Ascents	39	11	0
	£684	11	1
1860.			
Maintaining the Establishment of Kew Observatory	500	0	0
Dredging near Belfast	16	6	0
Dredging in Dublin Bay	15	0	0

	£	s.	d.
Inquiry into the Performance of Steam-vessels	124	0	0
Explorations in the Yellow Sandstone of Dura Den	20	0	0
Chemico-mechanical Analysis of Rocks and Minerals	25	0	0
Researches on the Growth of Plants	10	0	0
Researches on the Solubility of Salts	30	0	0
Researches on the Constituents of Manures	25	0	0
Balance of Captive Balloon Accounts	1	13	6
	£1241	7	0

1861.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	500	0	0
Earthquake Experiments	25	0	0
Dredging North and East Coasts of Scotland	23	0	0
Dredging Committee:— 1860 ...... £50 0 0; 1861 ...... £22 0 0	72	0	0
Excavations at Dura Den	20	0	0
Solubility of Salts	20	0	0
Steam-vessel Performance	150	0	0
Fossils of Lesmahago	15	0	0
Explorations at Uriconium	20	0	0
Chemical Alloys	20	0	0
Classified Index to the Transactions	100	0	0
Dredging in the Mersey and Dee	5	0	0
Dip Circle	30	0	0
Photoheliographic Observations	50	0	0
Prison Diet	20	0	0
Gauging of Water	10	0	0
Alpine Ascents	6	5	1
Constituents of Manures	25	0	0
	£1111	5	10

1862.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	500	0	0
Patent Laws	21	6	0
Mollusca of N.-W. America	10	0	0
Natural History by Mercantile Marine	5	0	0
Tidal Observations	25	0	0
Photoheliometer at Kew	40	0	0
Photographic Pictures of the Sun	150	0	0
Rocks of Donegal	25	0	0
Dredging Durham and Northumberland	25	0	0
Connexion of Storms	20	0	0
Dredging North-east Coast of Scotland	6	9	6
Ravages of Teredo	3	11	0
Standards of Electrical Resistance	50	0	0
Railway Accidents	10	0	0
Balloon Committee	200	0	0
Dredging Dublin Bay	10	0	0
Dredging the Mersey	5	0	0
Prison Diet	20	0	0
Gauging of Water	12	10	0
Steamships' Performance	150	0	0
Thermo-Electric Currents	5	0	0
	£1293	16	6

1863.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Balloon Committee deficiency	70	0	0
Balloon Ascents (other expenses)	25	0	0
Entozoa	25	0	0
Coal Fossils	20	0	0
Herrings	20	0	0
Granites of Donegal	5	0	0
Prison Diet	20	0	0
Vertical Atmospheric Movements	13	0	0
Dredging Shetland	50	0	0
Dredging North-east coast of Scotland	25	0	0
Dredging Northumberland and Durham	17	3	10
Dredging Committee superintendence	10	0	0
Steamship Performance	100	0	0
Balloon Committee	200	0	0
Carbon under pressure	10	0	0
Volcanic Temperature	100	0	0
Bromide of Ammonium	8	0	0
Electrical Standards	100	0	0
—— Construction and distribution	40	0	0
Luminous Meteors	17	0	0
Kew Additional Buildings for Photoheliograph	100	0	0
Thermo-Electricity	15	0	0
Analysis of Rocks	8	0	0
Hydroida	10	0	0
	£1608	3	10

1864.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Coal Fossils	20	0	0
Vertical Atmospheric Movements	20	0	0
Dredging Shetland	75	0	0
Dredging Northumberland	25	0	0
Balloon Committee	200	0	0
Carbon under pressure	10	0	0
Standards of Electric Resistance	100	0	0
Analysis of Rocks	10	0	0
Hydroida	10	0	0
Askham's Gift	50	0	0
Nitrite of Amyle	10	0	0
Nomenclature Committee	5	0	0
Rain-Gauges	19	15	8
Cast-Iron Investigation	20	0	0
Tidal Observations in the Humber	50	0	0
Spectral Rays	45	0	0
Luminous Meteors	20	0	0
	£1289	15	8

1865.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Balloon Committee	100	0	0
Hydroida	13	0	0

	£	s.	d.
Rain-Gauges	30	0	0
Tidal Observations in the Humber	6	8	0
Hexylic Compounds	20	0	0
Amyl Compounds	20	0	0
Irish Flora	25	0	0
American Mollusca	3	9	0
Organic Acids	20	0	0
Lingula Flags Excavation	10	0	0
Eurypterus	50	0	0
Electrical Standards	100	0	0
Malta Caves Researches	30	0	0
Oyster Breeding	25	0	0
Gibraltar Caves Researches	150	0	0
Kent's Hole Excavations	100	0	0
Moon's Surface Observations	35	0	0
Marine Fauna	25	0	0
Dredging Aberdeenshire	25	0	0
Dredging Channel Islands	50	0	0
Zoological Nomenclature	5	0	0
Resistance of Floating Bodies in Water	100	0	0
Bath Waters Analysis	8	10	0
Luminous Meteors	40	0	0
	£1591	7	10

1866.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Lunar Committee	64	13	4
Balloon Committee	50	0	0
Metrical Committee	50	0	0
British Rainfall	50	0	0
Kilkenny Coal Fields	16	0	0
Alum Bay Fossil Leaf-Bed	15	0	0
Luminous Meteors	50	0	0
Lingula Flags Excavation	20	0	0
Chemical Constitution of Cast Iron	50	0	0
Amyl Compounds	25	0	0
Electrical Standards	100	0	0
Malta Caves Exploration	30	0	0
Kent's Hole Exploration	200	0	0
Marine Fauna, &c., Devon and Cornwall	25	0	0
Dredging Aberdeenshire Coast	25	0	0
Dredging Hebrides Coast	50	0	0
Dredging the Mersey	5	0	0
Resistance of Floating Bodies in Water	50	0	0
Polycyanides of Organic Radicals	20	0	0
Rigor Mortis	10	0	0
Irish Annelida	15	0	0
Catalogue of Crania	50	0	0
Didine Birds of Mascarene Islands	50	0	0
Typical Crania Researches	30	0	0
Palestine Exploration Fund	100	0	0
	£1750	13	4

1867.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Meteorological Instruments, Palestine	50	0	0
Lunar Committee	120	0	0
Metrical Committee	30	0	0
Kent's Hole Explorations	100	0	0
Palestine Explorations	50	0	0
Insect Fauna, Palestine	30	0	0
British Rainfall	50	0	0
Kilkenny Coal Fields	25	0	0
Alum Bay Fossil Leaf-Bed	25	0	0
Luminous Meteors	50	0	0
Bournemouth, &c. Leaf-Beds	30	0	0
Dredging Shetland	75	0	0
Steamship Reports Condensation	100	0	0
Electrical Standards	100	0	0
Ethyle and Methyle series	25	0	0
Fossil Crustacea	25	0	0
Sound under Water	24	4	0
North Greenland Fauna	75	0	0
Do. Plant Beds	100	0	0
Iron and Steel Manufacture	25	0	0
Patent Laws	30	0	0
	£1739	4	0

1868.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Lunar Committee	120	0	0
Metrical Committee	50	0	0
Zoological Record	100	0	0
Kent's Hole Explorations	150	0	0
Steamship Performances	100	0	0
British Rainfall	50	0	0
Luminous Meteors	50	0	0
Organic Acids	60	0	0
Fossil Crustacea	25	0	0
Methyl series	25	0	0
Mercury and Bile	25	0	0
Organic remains in Limestone Rocks	25	0	0
Scottish Earthquakes	20	0	0
Fauna, Devon and Cornwall	30	0	0
British Fossil Corals	50	0	0
Bagshot Leaf-beds	50	0	0
Greenland Explorations	100	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature	50	0	0
Spectroscopic investigations of Animal Substances	5	0	0
Secondary Reptiles, &c.	30	0	0
British Marine Invertebrate Fauna	100	0	0
	£1940	0	0

1869.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Lunar Committee	50	0	0
Metrical Committee	25	0	0
Zoological Record	100	0	0
Committee on Gases in Deep-well Water	25	0	0
British Rainfall	50	0	0
Thermal Conductivity of Iron, &c.	30	0	0
Kent's Hole Explorations	150	0	0
Steamship Performances	30	0	0

	£	s.	d.
Chemical Constitution of Cast Iron	80	0	0
Iron and Steel Manufacture	100	0	0
Methyl Series	30	0	0
Organic remains in Limestone Rocks	10	0	0
Earthquakes in Scotland	10	0	0
British Fossil Corals	50	0	0
Bagshot Leaf-Beds	30	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature	30	0	0
Spectroscopic Investigations of Animal Substances	5	0	0
Organic Acids	12	0	0
Kiltorcan Fossils	20	0	0
Chemical Constitution and Physiological Action Relations	15	0	0
Mountain Limestone Fossils	25	0	0
Utilization of Sewage	10	0	0
Products of Digestion	10	0	0
	£1622	0	0

1870.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Metrical Committee	25	0	0
Zoological Record	100	0	0
Committee on Marine Fauna	20	0	0
Ears in Fishes	10	0	0
Chemical nature of Cast Iron	80	0	0
Luminous Meteors	30	0	0
Heat in the Blood	15	0	0
British Rainfall	100	0	0
Thermal Conductivity of Iron &c.	20	0	0
British Fossil Corals	50	0	0
Kent's Hole Explorations	150	0	0
Scottish Earthquakes	4	0	0
Bagshot Leaf-Beds	15	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature	50	0	0
Kiltorcan Quarries Fossils	20	0	0
Mountain Limestone Fossils	25	0	0
Utilization of Sewage	50	0	0
Organic Chemical Compounds	30	0	0
Onny River Sediment	3	0	0
Mechanical Equivalent of Heat	50	0	0
	£1572	0	0

1871.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Monthly Reports of Progress in Chemistry	100	0	0
Metrical Committee	25	0	0
Zoological Record	100	0	0
Thermal Equivalents of the Oxides of Chlorine	10	0	0
Tidal Observations	100	0	0
Fossil Flora	25	0	0
Luminous Meteors	30	0	0
British Fossil Corals	25	0	0
Heat in the Blood	7	2	6
British Rainfall	50	0	0
Kent's Hole Explorations	150	0	0
Fossil Crustacea	25	0	0
Methyl Compounds	25	0	0
Lunar Objects	20	0	0
Fossil Corals Sections, for Photographing	20	0	0
Bagshot Leaf-Beds	20	0	0
Moab Explorations	100	0	0
Gaussian Constants	40	0	0
	£1472	2	6

1872.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	300	0	0
Metrical Committee	75	0	0
Zoological Record	100	0	0
Tidal Committee	200	0	0
Carboniferous Corals	25	0	0
Organic Chemical Compounds	25	0	0
Exploration of Moab	100	0	0
Terato-Embryological Inquiries	10	0	0
Kent's Cavern Exploration	100	0	0
Luminous Meteors	20	0	0
Heat in the Blood	15	0	
Fossil Crustacea	25	0	0
Fossil Elephants of Malta	25	0	0
Lunar Objects	20	0	0
Inverse Wave-Lengths	20	0	0
British Rainfall	100	0	0
Poisonous Substances Antagonism	10	0	0
Essential Oils, Chemical Constitution, &c.	40	0	0
Mathematical Tables	50	0	0
Thermal Conductivity of Metals	25	0	0
	£1285	0	0

1873.

	£	s.	d.
Zoological Record	100	0	0
Chemistry Record	200	0	0
Tidal Committee	400	0	0
Sewage Committee	100	0	0
Kent's Cavern Exploration	150	0	0
Carboniferous Corals	25	0	0
Fossil Elephants	25	0	0
Wave-Lengths	150	0	0
British Rainfall	100	0	0
Essential Oils	30	0	0
Mathematical Tables	100	0	0
Gaussian Constants	10	0	0
Sub-Wealden Explorations	25	0	0
Underground Temperature	150	0	0
Settle Cave Exploration	50	0	0
Fossil Flora, Ireland	20	0	0
Timber Denudation and Rainfall	20	0	0
Luminous Meteors	30	0	0
	£1685	0	0

	£	s.	d.
1874.			
Zoological Record	100	0	0
Chemistry Record	100	0	0
Mathematical Tables	100	0	0
Elliptic Functions	100	0	0
Lightning Conductors	10	0	0
Thermal Conductivity of Rocks	10	0	0
Anthropological Instructions, &c.	50	0	0
Kent's Cavern Exploration	150	0	0
Luminous Meteors	30	0	0
Intestinal Secretions	15	0	0
British Rainfall	100	0	0
Essential Oils	10	0	0
Sub-Wealden Explorations	25	0	0
Settle Cave Exploration	50	0	0
Mauritius Meteorological Research	100	0	0
Magnetization of Iron	20	0	0
Marine Organisms	30	0	0
Fossils, North-west of Scotland	2	10	0
Physiological Action of Light	20	0	0
Trades Unions	25	0	0
Mountain-Limestone Corals	25	0	0
Erratic Blocks	10	0	0
Dredging, Durham and Yorkshire Coasts	28	5	0
High temperature of Bodies	30	0	0
Siemens's Pyrometer	3	6	0
Labyrinthodont, of Coal-Measures	7	15	0
	£1151	16	0

General Meetings.

On Wednesday Evening, August 19, at 8 P.M., in the Ulster Hall, Professor Alexander W. Williamson, Ph.D., F.R.S., President, resigned the office of President to Professor John Tyndall, D.C.L., LL.D., F.R.S., who took the Chair, and delivered an Address, for which see page lxvi.

On Thursday Evening, August 20, at 8 P.M., a Soirée took place in the Ulster Hall.

On Friday Evening, August 21, at 8.30 P.M., in the Ulster Hall, Sir John Lubbock, Bart., M.P., F.R.S., delivered a Discourse on "Common Wild Flowers considered in relation to Insects."

On Saturday Evening, August 22, at 7.30 P.M., in the Working Men's Institute, Professor Odling, F.R.S., delivered a Lecture on "The Discovery of Oxygen" to the Working Classes of Belfast.

On Monday Evening, August 24, at 8.30 P.M., in the Ulster Hall, Professor Huxley, LL.D., F.R.S., delivered a Discourse on "The Hypothesis that Animals are Automata, and its History."

On Tuesday Evening, August 25, at 8 P.M., a Soirée took place in the Ulster Hall.

On Wednesday, August 26, at 2.30 P.M., the concluding General Meeting took place, when the Proceedings of the General Committee, and the Grants of Money for Scientific purposes, were explained to the Members.

The Meeting was then adjourned to Bristol*.

* The Meeting is appointed to take place on Wednesday, August 25, 1875.

ADDRESS

OF

JOHN TYNDALL, F.R.S.,

D.C.L. OXON., LL.D. CANTAB., F.C.P.S.,

PROFESSOR OF NATURAL PHILOSOPHY IN THE ROYAL INSTITUTION,

PRESIDENT.

An impulse inherent in primeval man turned his thoughts and questionings betimes towards the sources of natural phenomena. The same impulse, inherited and intensified, is the spur of scientific action to-day. Determined by it, by a process of abstraction from experience we form physical theories which lie beyond the pale of experience, but which satisfy the desire of the mind to see every natural occurrence resting upon a cause. In forming their notions of the origin of things, our earliest historic (and doubtless, we might add, our prehistoric) ancestors pursued, as far as their intelligence permitted, the same course. They also fell back upon experience, but with this difference—that the particular experiences which furnished the weft and woof of their theories were drawn, not from the study of nature, but from what lay much closer to them, the observation of men. Their theories accordingly took an anthropomorphic form. To supersensual beings, which, "however potent and invisible, were nothing but a species of human creatures, perhaps raised from among mankind, and retaining all human passions and appetites"*, were handed over the rule and governance of natural phenomena.

Tested by observation and reflection, these early notions failed in the long run to satisfy the more penetrating intellects of our race. Far in the depths of history we find men of exceptional power differentiating themselves from the crowd, rejecting these anthropomorphic notions, and seeking to connect natural phenomena with their physical principles. But long prior to these purer efforts of the understanding the merchant had been abroad, and rendered the philosopher possible; commerce had been developed, wealth amassed, leisure for travel and speculation secured, while races educated under different conditions, and therefore differently informed and endowed, had been stimulated and sharpened by mutual contact. In those regions where the commercial aristocracy of ancient Greece mingled with its eastern neighbours, the sciences were born, being nurtured and developed by free-thinking and courageous men. The state of things to be displaced may be gathered from a passage of Euripides quoted by Hume. "There is nothing

* Hume, 'Natural History of Religion.'

in the world; no glory, no prosperity. The gods toss all into confusion; mix every thing with its reverse, that all of us, from our ignorance and uncertainty, may pay them the more worship and reverence." Now, as science demands the radical extirpation of caprice and the absolute reliance upon law in nature, there grew with the growth of scientific notions a desire and determination to sweep from the field of theory this mob of gods and demons, and to place natural phenomena on a basis more congruent with themselves.

The problem which had been previously approached from above, was now attacked from below; theoretic effort passed from the super- to the subsensible. It was felt that to construct the universe in idea it was necessary to have some notion of its constituent parts—of what Lucretius subsequently called the "First Beginnings." Abstracting again from experience, the leaders of scientific speculation reached at length the pregnant doctrine of atoms and molecules, the latest developments of which were set forth with such power and clearness at the last meeting of the British Association. Thought no doubt had long hovered about this doctrine before it attained the precision and completeness which it assumed in the mind of Democritus*, a philosopher who may well for a moment arrest our attention. "Few great men," says Lange, a non-materialist, in his excellent 'History of Materialism,' to the spirit and to the letter of which I am equally indebted, "have been so despitefully used by history as Democritus. In the distorted images sent down to us through unscientific traditions there remains of him almost nothing but the name of 'the laughing philosopher,' while figures of immeasurably smaller significance spread themselves out at full length before us." Lange speaks of Bacon's high appreciation of Democritus—for ample illustrations of which I am indebted to my excellent friend Mr. Spedding, the learned editor and biographer of Bacon. It is evident, indeed, that Bacon considered Democritus to be a man of weightier metal than either Plato or Aristotle, though their philosophy "was noised and celebrated in the schools, amid the din and pomp of professors." It was not they, but Genseric and Attila and the barbarians, who destroyed the atomic philosophy. "For at a time when all human learning had suffered shipwreck, these planks of Aristotelian and Platonic philosophy, as being of a lighter and more inflated substance, were preserved and came down to us, while things more solid sank and almost passed into oblivion."

The son of a wealthy father, Democritus devoted the whole of his inherited fortune to the culture of his mind. He travelled everywhere; visited Athens when Socrates and Plato were there, but quitted the city without making himself known. Indeed, the dialectic strife in which Socrates so much delighted had no charm for Democritus, who held that "the man who readily contradicts and uses many words is unfit to learn any thing truly right." He is said to have discovered and educated Protagoras the sophist, being struck as much by the manner in which he, being a hewer of wood, tied up his faggots as by the sagacity of his conversation. Democritus returned poor from his travels, was supported by his brother, and at length wrote his great work entitled 'Diakosmos,' which he read publicly before the people of his native town. He was honoured by his countrymen in various ways, and died serenely at a great age.

The principles enunciated by Democritus reveal his uncompromising antagonism to those who deduced the phenomena of nature from the caprices of the

* Born 460 B.C.

gods. They are briefly these :—1. From nothing comes nothing. Nothing that exists can be destroyed. All changes are due to the combination and separation of molecules. 2. Nothing happens by chance. Every occurrence has its cause from which it follows by necessity. 3. The only existing things are the atoms and empty space; all else is mere opinion. 4. The atoms are infinite in number, and infinitely various in form; they strike together, and the lateral motions and whirlings which thus arise are the beginnings of worlds. 5. The varieties of all things depend upon the varieties of their atoms, in number, size, and aggregation. 6. The soul consists of fine, smooth, round atoms, like those of fire. These are the most mobile of all. They interpenetrate the whole body, and in their motions the phenomena of life arise. The first five propositions are a fair general statement of the atomic philosophy, as now held. As regards the sixth, Democritus made his fine smooth atoms do duty for the nervous system, whose functions were then unknown. The atoms of Democritus are individually without sensation; they combine in obedience to mechanical laws; and not only organic forms, but the phenomena of sensation and thought are the result of their combination.

That great enigma, "the exquisite adaptation of one part of an organism to another part, and to the conditions of life," more especially the construction of the human body, Democritus made no attempt to solve. Empedocles, a man of more fiery and poetic nature, introduced the notion of love and hate among the atoms to account for their combination and separation. Noticing this gap in the doctrine of Democritus, he struck in with the penetrating thought, linked, however, with some wild speculation, that it lay in the very nature of those combinations which were suited to their ends (in other words, in harmony with their environment) to maintain themselves, while unfit combinations, having no proper habitat, must rapidly disappear. Thus more than 2000 years ago the doctrine of the "survival of the fittest," which in our day, not on the basis of vague conjecture, but of positive knowledge, has been raised to such extraordinary significance, had received at all events partial enunciation *.

Epicurus †, said to be the son of a poor schoolmaster at Samos, is the next dominant figure in the history of the atomic philosophy. He mastered the writings of Democritus, heard lectures in Athens, went back to Samos, and subsequently wandered through various countries. He finally returned to Athens, where he bought a garden, and surrounded himself by pupils, in the midst of whom he lived a pure and serene life, and died a peaceful death. Democritus looked to the soul as the ennobling part of man; even beauty without understanding partook of animalism. Epicurus also rated the spirit above the body; the pleasure of the body was that of the moment, while the spirit could draw upon the future and the past. His philosophy was almost identical with that of Democritus; but he never quoted either friend or foe. One main object of Epicurus was to free the world from superstition and the fear of death. Death he treated with indifference. It merely robs us of sensation. As long as we are, death is not; and when death is, we are not. Life has no more evil for him who has made up his mind that it is no evil not to live. He adored the gods, but not in the ordinary fashion. The idea of divine power, properly purified, he thought an elevating one. Still he taught, "Not he is godless who rejects the gods of the crowd, but rather he who accepts them." The gods were to him eternal

* Lange, 2nd edit., p. 23.

† Born 342 B.C.

and immortal beings, whose blessedness excluded every thought of care or occupation of any kind. Nature pursues her course in accordance with everlasting laws, the gods never interfering. They haunt

> "The lucid interspace of world and world
> Where never creeps a cloud or moves a wind,
> Nor ever falls the least white star of snow,
> Nor ever lowest roll of thunder moans,
> Nor sound of human sorrow mounts to mar
> Their sacred everlasting calm" *.

Lange considers the relation of Epicurus to the gods subjective; the indication probably of an ethical requirement of his own nature. We cannot read history with open eyes, or study human nature to its depths, and fail to discern such a requirement. Man never has been, and he never will be satisfied with the operations and products of the Understanding alone; hence physical science cannot cover all the demands of his nature. But the history of the efforts made to satisfy these demands might be broadly described as a history of errors—the error in great part consisting in ascribing fixity to that which is fluent, which varies as we vary, being gross when we are gross, and becoming, as our capacities widen, more abstract and sublime. On one great point the mind of Epicurus was at peace. He neither sought nor expected, here or hereafter, any personal profit from his relation to the gods. And it is assuredly a fact that loftiness and serenity of thought may be promoted by conceptions which involve no idea of profit of this kind. "Did I not believe," said a great man to me once, "that an Intelligence is at the heart of things, my life on earth would be intolerable." The utterer of these words is not, in my opinion, rendered less noble but more noble, by the fact that it was the need of ethical harmony here, and not the thought of personal profit hereafter, that prompted his observation.

There are persons, not belonging to the highest intellectual zone, nor yet to the lowest, to whom perfect clearness of exposition suggests want of depth. They find comfort and edification in an abstract and learned phraseology. To some such people Epicurus, who spared no pains to rid his style of every trace of haze and turbidity, appeared, on this very account, superficial. He had, however, a disciple who thought it no unworthy occupation to spend his days and nights in the effort to reach the clearness of his master, and to whom the Greek philosopher is mainly indebted for the extension and perpetuation of his fame. Some two centuries after the death of Epicurus, Lucretius † wrote his great poem, "On the Nature of Things," in which he, a Roman, developed with extraordinary ardour the philosophy of his Greek predecessor. He wishes to win over his friend Memnius to the school of Epicurus; and although he has no rewards in a future life to offer, although his object appears to be a purely negative one, he addresses his friend with the heat of an apostle. His object, like that of his great forerunner, is the destruction of superstition; and considering that men trembled before every natural event as a direct monition from the gods, and that everlasting torture was also in prospect, the freedom aimed at by Lucretius might perhaps be deemed a positive good. "This terror," he says, "and darkness of mind must be dispelled, not by the rays of the sun and glittering shafts of day, but by the aspect and the law of nature." He refutes the notion that any thing can come out of nothing, or that that which is once begotten can be recalled to nothing. The first beginnings, the

* Tennyson's 'Lucretius.'

† Born 99 B.C.

atoms, are indestructible, and into them all things can be resolved at last. Bodies are partly atoms, and partly combinations of atoms; but the atoms nothing can quench. They are strong in solid singleness, and by their denser combination, all things can be closely packed and exhibit enduring strength. He denies that matter is infinitely divisible. We come at length to the atoms, without which, as an imperishable substratum, all order in the generation and development of things would be destroyed.

The mechanical shock of the atoms being in his view the all-sufficient cause of things, he combats the notion that the constitution of nature has been in any way determined by intelligent design. The interaction of the atoms throughout infinite time rendered all manner of combinations possible. Of these the fit ones persisted, while the unfit ones disappeared. Not after sage deliberation did the atoms station themselves in their right places, nor did they bargain what motions they should assume. From all eternity they have been driven together, and after trying motions and unions of every kind, they fell at length into the arrangements out of which this system of things has been formed. "If you will apprehend and keep in mind these things, nature, free at once, and rid of her haughty lords, is seen to do all things spontaneously of herself, without the meddling of the gods"*.

To meet the objection that his atoms cannot be seen, Lucretius describes a violent storm, and shows that the invisible particles of air act in the same way as the visible particles of water. We perceive, moreover, the different smells of things, yet never see them coming to our nostrils. Again, clothes hung up on a shore which waves break upon become moist, and then get dry if spread out in the sun, though no eye can see either the approach or the escape of the water particles. A ring, worn long on the fingers, becomes thinner; a water drop hollows out a stone; the ploughshare is rubbed away in the field; the street pavement is worn by the feet; but the particles that disappear at any moment we cannot see. Nature acts through invisible particles. That Lucretius had a strong scientific imagination the foregoing references prove. A fine illustration of his power in this respect is his explanation of the apparent rest of bodies whose atoms are in motion. He employs the image of a flock of sheep with skipping lambs, which, seen from a distance, presents simply a white patch upon the green hill, the jumping of the individual lambs being quite invisible.

His vaguely grand conception of the atoms falling eternally through space suggested the nebular hypothesis to Kant, its first propounder. Far beyond the limits of our visible world are to be found atoms innumerable, which have never been united to form bodies, or which, if once united, have been again dispersed, falling silently through immeasurable intervals of time and space. As everywhere throughout the All the same conditions are repeated, so must the phenomena be repeated also. Above us, below us, beside us, therefore, are worlds without end; and this, when considered, must dissipate every thought of a deflection of the universe by the gods. The worlds come and go, attracting new atoms out of limitless space, or dispersing their own particles. The reputed death of Lucretius, which forms the basis of Mr. Tennyson's noble poem, is in strict accordance with his philosophy, which was severe and pure.

Still earlier than these three philosophers, and during the centuries between

* Monro's translation. In his criticism of this work (Contemporary Review, 1867) Dr. Hayman does not appear to be aware of the really sound and subtile observations on which the reasoning of Lucretius, though erroneous, sometimes rests.

the first of them and the last, the human intellect was active in other fields than theirs. Pythagoras had founded a school of mathematics and made his experiments on the harmonic intervals. The sophists had run through their career. At Athens had appeared Socrates, Plato, and Aristotle, who ruined the sophists, and whose yoke remains to some extent unbroken to the present hour. Within this period also the School of Alexandria was founded, Euclid wrote his 'Elements,' and made some advance in optics. Archimedes had propounded the theory of the lever, and the principles of hydrostatics. Astronomy was immensely enriched by the discoveries of Hipparchus, who was followed by the historically more celebrated Ptolemy. Anatomy had been made the basis of Scientific medicine; and it is said by Draper* that vivisection had begun. In fact the science of ancient Greece had already cleared the world of the fantastic images of divinities operating capriciously through natural phenomena. It had shaken itself free from that fruitless scrutiny "by the internal light of the mind alone," which had vainly sought to transcend experience and reach a knowledge of ultimate causes. Instead of accidental observation, it had introduced observation with a purpose; instruments were employed to aid the senses; and scientific method was rendered in a great measure complete by the union of Induction and Experiment.

What, then, stopped its victorious advance? Why was the scientific intellect compelled, like an exhausted soil, to lie fallow for nearly two millenniums before it could regather the elements necessary to its fertility and strength? Bacon has already let us know one cause; Whewell ascribes this stationary period to four causes—obscurity of thought, servility, intolerance of disposition, enthusiasm of temper; and he gives striking examples of each†. But these characteristics must have had their antecedents in the circumstances of the time. Rome, and the other cities of the Empire, had fallen into moral putrefaction. Christianity had appeared, offering the gospel to the poor, and, by moderation if not asceticism of life, practically protesting against the profligacy of the age. The sufferings of the early christians and the extraordinary exaltation of mind which enabled them to triumph over the diabolical tortures to which they were subjected‡, must have left traces not easily effaced. They scorned the earth, in view of that "building of God, that house not made with hands, eternal in the heavens." The Scriptures which ministered to their spiritual needs were also the measure of their Science. When, for example, the celebrated question of antipodes came to be discussed, the Bible was with many the ultimate court of appeal. Augustine, who flourished A.D. 400, would not deny the rotundity of the earth; but he would deny the possible existence of inhabitants at the other side, "because no such race is recorded in Scripture among the descendants of Adam." Archbishop Boniface was shocked at the assumption of a "world of human beings out of the reach of the means of salvation." Thus reined in, Science was not likely to make much progress. Later on the political and theological strife between the Church and civil governments, so powerfully depicted by Draper, must have done much to stifle investigation.

Whewell makes many wise and brave remarks regarding the spirit of the Middle Ages. It was a menial spirit. The seekers after natural knowledge had forsaken that fountain of living waters, the direct appeal to nature by observation and experiment, and had given themselves up to the remanipula-

* History of the Intellectual Development of Europe, p. 295.
† History of the Inductive Sciences, vol. i.
‡ Depicted with terrible vividness in Rénan's 'Antichrist.'

tion of the notions of their predecessors. It was a time when thought had become abject, and when the acceptance of mere authority led, as it always does in science, to intellectual death. Natural events, instead of being traced to physical, were referred to moral causes; while an exercise of the phantasy, almost as degrading as the spiritualism of the present day, took the place of scientific speculation. Then came the mysticism of the Middle Ages, Magic, Alchemy, the Neo-platonic philosophy, with its visionary though sublime abstractions, which caused men to look with shame upon their own bodies as hindrances to the absorption of the creature in the blessedness of the Creator. Finally came the Scholastic philosophy, a fusion, according to Lange, of the least-mature notions of Aristotle with the Christianity of the west. Intellectual immobility was the result. As a traveller without a compass in a fog may wander long, imagining he is making way, and find himself after hours of toil at his starting-point, so the schoolmen, having tied and untied the same knots and formed and dissipated the same clouds, found themselves at the end of centuries in their old position.

With regard to the influence wielded by Aristotle in the Middle Ages, and which, though to a less extent, he still wields, I would ask permission to make one remark. When the human mind has achieved greatness and given evidence of extraordinary power in any domain, there is a tendency to credit it with similar power in all other domains. Thus theologians have found comfort and assurance in the thought that Newton dealt with the question of revelation, forgetful of the fact that the very devotion of his powers, through all the best years of his life, to a totally different class of ideas, not to speak of any natural disqualification, tended to render him less instead of more competent to deal with theological and historic questions. Goethe, starting from his established greatness as a poet, and indeed from his positive discoveries in Natural History, produced a profound impression among the painters of Germany, when he published his 'Farbenlehre,' in which he endeavoured to overthrow Newton's theory of colours. This theory he deemed so obviously absurd, that he considered its author a charlatan, and attacked him with a corresponding vehemence of language. In the domain of natural history Goethe had made really considerable discoveries; and we have high authority for assuming that, had he devoted himself wholly to that side of science, he might have reached in it an eminence comparable with that which he attained as a poet. In sharpness of observation, in the detection of analogies however apparently remote, in the classification and organization of facts according to the analogies discerned, Goethe possessed extraordinary powers. These elements of scientific inquiry fall in with the discipline of the poet. But, on the other hand, a mind thus richly endowed in the direction of natural history, may be almost shorn of endowment as regards the more strictly called physical and mechanical sciences. Goethe was in this condition. He could not formulate distinct mechanical conceptions; he could not see the force of mechanical reasoning; and in regions where such reasoning reigns supreme he became a mere *ignis fatuus* to those who followed him.

I have sometimes permitted myself to compare Aristotle with Goethe, to credit the Stagirite with an almost superhuman power of amassing and systematizing facts, but to consider him fatally defective on that side of the mind in respect to which incompleteness has been just ascribed to Goethe. Whewell refers the errors of Aristotle, not to a neglect of facts, but to "a neglect of the idea appropriate to the facts; the idea of Mechanical cause, which is Force, and the substitution of vague or inapplicable notions, involving only

relations of space or emotions of wonder." This is doubtless true; but the word "neglect" implies mere intellectual misdirection, whereas in Aristotle, as in Goethe, it was not, I believe, misdirection, but sheer natural incapacity which lay at the root of his mistakes. As a physicist, Aristotle displayed what we should consider some of the worst attributes of a modern physical investigator—indistinctness of ideas, confusion of mind, and a confident use of language, which led to the delusive notion that he had really mastered his subject, while he had as yet failed to grasp even the elements of it. He put words in the place of things, subject in the place of object. He preached Induction without practising it, inverting the true order of inquiry by passing from the general to the particular, instead of from the particular to the general. He made of the universe a closed sphere, in the centre of which he fixed the earth, proving from general principles, to his own satisfaction and to that of the world for near 2000 years, that no other universe was possible. His notions of motion were entirely unphysical. It was natural or unnatural, better or worse, calm or violent—no real mechanical conception regarding it lying at the bottom of his mind. He affirmed that a vacuum could not exist, and proved that if it did exist motion in it would be impossible. He determined *à priori* how many species of animals must exist, and shows on general principles why animals must have such and such parts. When an eminent contemporary philosopher, who is far removed from errors of this kind, remembers these abuses of the *à priori* method, he will be able to make allowance for the jealousy of physicists as to the acceptance of so-called *à priori* truths. Aristotle's errors of detail, as shown by Eucken and Lange, were grave and numerous. He affirmed that only in man we had the beating of the heart, that the left side of the body was colder than the right, that men have more teeth than women, and that there is an empty space at the back of every man's head.

There is one essential quality in physical conceptions which was entirely wanting in those of Aristotle and his followers. I wish it could be expressed by a word untainted by its associations; it signifies a capability of being placed as a coherent picture before the mind. The Germans express the act of picturing by the word *vorstellen*, and the picture they call a *Vorstellung*. We have no word in English which comes nearer to our requirements than *Imagination*, and, taken with its proper limitations, the word answers very well; but, as just intimated, it is tainted by its associations, and therefore objectionable to some minds. Compare, with reference to this capacity of mental presentation, the case of the Aristotelian, who refers the ascent of water in a pump to Nature's abhorrence of a vacuum, with that of Pascal when he proposed to solve the question of atmospheric pressure by the ascent of the Puy de Dôme. In the one case the terms of the explanation refuse to fall into place as a physical image; in the other the image is distinct, the fall and rise of the barometer being clearly figured as the balancing of two varying and opposing pressures.

During the drought of the Middle Ages in Christendom, the Arabian intellect, as forcibly shown by Draper, was active. With the intrusion of the Moors into Spain, he says, order, learning, and refinement took the place of their opposites. When smitten with disease, the Christian peasant resorted to a shrine, the Moorish one to an instructed physician. The Arabs encouraged translations from the Greek philosophers, but not from the Greek poets. They turned in disgust "from the lewdness of our classical mythology, and denounced as an unpardonable blasphemy all connexion between the impure Olympian Jove and the Most High God." Draper traces still further than

Whewell the Arab elements in our scientific terms, and points out that the under garment of ladies retains to this hour its Arab name. He gives examples of what Arabian men of science accomplished, dwelling particularly on Alhazen, who was the first to correct the Platonic notion that rays of light are emitted by the eye. He discovered atmospheric refraction, and points out that we see the sun and the moon after they have set. He explains the enlargement of the sun and moon, and the shortening of the vertical diameters of both these bodies, when near the horizon. He is aware that the atmosphere decreases in density with increase of elevation, and actually fixes its height at $58\frac{1}{2}$ miles. In the Book of the Balance Wisdom, he sets forth the connexion between the weight of the atmosphere and its increasing density. He shows that a body will weigh differently in a rare and dense atmosphere: he considers the force with which plunged bodies rise through heavier media. He understands the doctrine of the centre of gravity, and applies it to the investigation of balances and steelyards. He recognizes gravity as a force, though he falls into the error of making it diminish simply as the distance increased, and of making it purely terrestrial. He knows the relation between the velocities, spaces, and times of falling bodies, and has distinct ideas of capillary attraction. He improved the hydrometer. The determination of the densities of bodies as given by Alhazen approach very closely to our own. "I join," says Draper, in the pious prayer of Alhazen, "that in the day of judgment the All-Merciful will take pity on the soul of Abur-Raihân, because he was the first of the race of men to construct a table of specific gravities." If all this be historic truth (and I have entire confidence in Dr. Draper), well may he "deplore the systematic manner in which the literature of Europe has contrived to put out of sight our scientific obligations to the Mahommedans"*.

The strain upon the mind during the stationary period towards ultra-terrestrial things to the neglect of problems close at hand, was sure to provoke reaction. But the reaction was gradual; for the ground was dangerous, a power being at hand competent to crush the critic who went too far. To elude this power and still allow opportunity for the expression of opinion, the doctrine of "twofold truth" was invented, according to which an opinion might be held "theologically," and the opposite opinion "philosophically"†. Thus, in the thirteenth century, the creation of the world in six days, and the unchangeableness of the individual soul, which had been so distinctly affirmed by St. Thomas Aquinas, were both denied philosophically, but admitted to be true as articles of the Catholic faith. When Protagoras uttered the maxim which brought upon him so much vituperation, that "opposite assertions are equally true," he simply meant that human beings differed so much from each other that what was subjectively true to the one might be subjectively untrue to the other. The great Sophist never meant to play fast and loose with the truth by saying that one of two opposite assertions, made by the same individual, could possibly escape being a lie. It was not "sophistry," but the dread of theologic vengeance that generated this double dealing with conviction; and it is astonishing to notice what lengths were possible to men who were adroit in the use of artifices of this kind.

Towards the close of the stationary period a word-weariness, if I may so express it, took more and more possession of men's minds. Christendom had become sick of the School philosophy and its verbal wastes, which led to no

* Intellectual Development of Europe, p. 359.

† Lange, 2nd edit. pp. 181, 182.

issue, but left the intellect in everlasting haze. Here and there was heard the voice of one impatiently crying in the wilderness, "Not unto Aristotle, not unto subtle hypothesis, not unto church, bible, or blind tradition, must we turn for a knowledge of the universe, but to the direct investigation of nature by observation and experiment." In 1543 the epoch-making work of Copernicus on the paths of the heavenly bodies appeared. The total crash of Aristotle's closed universe with the earth at its centre followed as a consequence; and "the earth moves" became a kind of watchword among intellectual freemen. Copernicus was Canon of the church of Frauenburg in the diocese of Ermeland. For three-and-thirty years he had withdrawn himself from the world and devoted himself to the consolidation of his great scheme of the solar system. He made its blocks eternal; and even to those who feared it and desired its overthrow it was so obviously strong that they refrained for a time from meddling with it. In the last year of the life of Copernicus his book appeared: it is said that the old man received a copy of it a few days before his death, and then departed in peace.

The Italian philosopher Giordano Bruno was one of the earliest converts to the new astronomy. Taking Lucretius as his exemplar, he revived the notion of the infinity of worlds; and combining with it the doctrine of Copernicus, reached the sublime generalization that the fixed stars are suns, scattered numberless through space and accompanied by satellites, which bear the same relation to them that our earth does to our sun, or our moon to our earth. This was an expansion of transcendent import; but Bruno came closer than this to our present line of thought. Struck with the problem of the generation and maintenance of organisms, and duly pondering it, he came to the conclusion that Nature in her productions does not imitate the technic of man. Her process is one of unravelling and unfolding. The infinity of forms under which matter appears were not imposed upon it by an external artificer; by its own intrinsic force and virtue it brings these forms forth. Matter is not the mere naked, empty *capacity* which philosophers have pictured her to be, but the universal mother, who brings forth all things as the fruit of her own womb.

This outspoken man was originally a Dominican monk. He was accused of heresy and had to fly, seeking refuge in Geneva, Paris, England, and Germany. In 1592 he fell into the hands of the Inquisition at Venice. He was imprisoned for many years, tried, degraded, excommunicated, and handed over to the Civil power, with the request that he should be treated gently and "without the shedding of blood." This meant that he was to be burnt; and burnt accordingly he was, on the 16th of February, 1600. To escape a similar fate Galileo, 33 years afterwards, abjured, upon his knees and with his hand upon the holy gospels, the heliocentric doctrine which he knew to be true. After Galileo came Kepler, who from his German home defied the power beyond the Alps. He traced out from preexisting observations the laws of planetary motion. Materials were thus prepared for Newton, who bound those empirical laws together by the principle of gravitation.

In the seventeenth century Bacon and Descartes, the restorers of philosophy, appeared in succession. Differently educated and endowed, their philosophic tendencies were different. Bacon held fast to Induction, believing firmly in the existence of an external world, and making collected experiences the basis of all knowledge. The mathematical studies of Descartes gave him a bias towards Deduction; and his fundamental principle was much the same as that of Protagoras, who made the individual man the measure of all things. "I think, therefore, I am," said Descartes. Only

his own identity was sure to him; and the development of this system would have led to an idealism in which the outer world would be resolved into a mere phenomenon of consciousness. Gassendi, one of Descartes's contemporaries, of whom we shall hear more presently, quickly pointed out that the fact of personal existence would be proved as well by reference to any other act as to the act of thinking. I eat, therefore I am; or I love, therefore I am, would be quite as conclusive. Lichtenberg showed that the very thing to be proved was inevitably postulated in the first two words, "I think;" and that no inference from the postulate could by any possibility be stronger than the postulate itself.

But Descartes deviated strangely from the idealism implied in his fundamental principle. He was the first to reduce, in a manner eminently capable of bearing the test of mental presentation, vital phenomena to purely mechanical principles. Through fear or love, Descartes was a good churchman; he accordingly rejects the notions of an atom, because it was absurd to suppose that God, if he so pleased, could not divide an atom; he puts in the place of the atoms small round particles and light splinters, out of which he builds the organism. He sketches with marvellous physical insight a machine, with water for its motive power, which shall illustrate vital actions. He has made clear to his mind that such a machine would be competent to carry on the processes of digestion, nutrition, growth, respiration, and the beating of the heart. It would be competent to accept impressions from the external sense, to store them up in imagination and memory, to go through the internal movements of the appetites and passions, the external movement of limbs. He deduces these functions of his machine from the mere arrangement of its organs, as the movement of a clock or other automaton is deduced from its weights and wheels. "As far as these functions are concerned," he says, "It is not necessary to conceive any other vegetative or sensitive soul, nor any other principle of motion or of life, than the blood and the spirits agitated by the fire which burns continually in the heart, and which is in nowise different from the fires which exist in inanimate bodies. Had Descartes been acquainted with the steam-engine, he would have taken it, instead of a fall of water, as his motive power, and shown the perfect analogy which exists between the oxidation of the food in the body and that of the coal in the furnace. He would assuredly have anticipated Mayer in calling the blood which the heart diffuses, "the oil of the lamp of life;" deducing all animal motions from the combustion of this oil, as the motions of a steam-engine are deduced from the combustion of its coals. As the matter stands, however, and considering the circumstances of the time, the boldness, clearness, and precision with which he grasped the problem of vital dynamics constitute a marvellous illustration of intellectual power*.

During the Middle Ages the doctrine of atoms had to all appearance vanished from discussion. In all probability it held its ground among sober-minded and thoughtful men, though neither the church nor the world was prepared to hear of it with tolerance. Once, in the year 1348, it received distinct expression. But retraction by compulsion immediately followed; and thus discouraged, it slumbered till the 17th century, when it was revived by a contemporary and friend of Hobbes of Malmesbury, the orthodox Catholic provost of Digne, Gassendi. But before stating his relation to the Epicurian doctrine, it will be well to say a few words on the effect, as regards science, of the general introduction of monotheism among European nations.

* See Huxley's admirable Essay on Descartes. Lay Sermons, pp. 364, 365.

"Were men," says Hume, "led into the apprehension of invisible intelligent power by contemplation of the works of Nature, they could never possibly entertain any conception but of one single being, who bestowed existence and order on this vast machine, and adjusted all its parts to one regular system." Referring to the condition of the heathen, who sees a god behind every natural event, thus peopling the world with thousands of beings whose caprices are incalculable, Lange shows the impossibility of any compromise between such notions and those of science, which proceeds on the assumption of never-changing law and causality. "But," he continues, with characteristic penetration, "when the great thought of one God, acting as a unit upon the universe, has been seized, the connexion of things in accordance with the law of cause and effect is not only thinkable, but it is a necessary consequence of the assumption. For when I see ten thousand wheels in motion, and know, or believe, that they are all driven by one, then I know that I have before me a mechanism, the action of every part of which is determined by the plan of the whole. So much being assumed, it follows that I may investigate the structure of that machine, and the various motions of its parts. For the time being, therefore, this conception renders scientific action free." In other words, were a capricious God at the circumference of every wheel and at the end of every lever, the action of the machine would be incalculable by the methods of science. But the action of all its parts being rigidly determined by their connexions and relations, and these being brought into play by a single self-acting driving wheel, then, though this last prime mover may elude me, I am still able to comprehend the machinery which it sets in motion. We have here a conception of the relation of Nature to its Author, which seems perfectly acceptable to some minds, but perfectly intolerable to others. Newton and Boyle lived and worked happily under the influence of this conception; Goethe rejected it with vehemence, and the same repugnance to accepting it is manifest in Carlyle*.

The analytic and synthetic tendencies of the human mind exhibit themselves throughout history, great writers ranging themselves sometimes on the one side, sometimes on the other. Men of warm feelings, and minds open to the elevating impressions produced by nature as a whole, whose satisfaction, therefore, is rather ethical than logical, lean to the synthetic side; while the analytic harmonizes best with the more precise and more mechanical bias which seeks the satisfaction of the understanding. Some form of pantheism was usually adopted by the one, while a detached Creator, working more or less after the manner of men, was often assumed by the other. Gassendi, as sketched by Lange, is hardly to be ranked with either. Having formally acknowledged God as the great first cause, he immediately dropped the idea, applied the known laws of mechanics to the atoms, deducing thence all vital phenomena. He defended Epicurus, and dwelt upon his purity, both of doctrine and of life. True he was a heathen, but so was Aristotle. He assailed superstition and religion, and rightly, because he did not know the true religion. He thought that the gods neither rewarded nor punished, and adored them purely in consequence of their completeness; here we see, says Gassendi, the reverence of the child instead of the fear of the slave. The errors of Epicurus shall be corrected, the body of his truth

* Boyle's model of the universe was the Strasburg clock with an outside Artificer. Goethe, on the other hand, sang

"Ihm ziemt's die Welt im Innern zu bewegen,
Natur in sich, sich in Natur zu hegen."

See also Carlyle, 'Past and Present,' chap. v.

retained; and then Gassendi proceeds, as any heathen might do, to build up the world, and all that therein is, of atoms and molecules. God, who created earth and water, plants and animals, produced in the first place a definite number of atoms, which constituted the seed of all things. Then began that series of combinations and decompositions which goes on at present, and which will continue in future. The principle of every change resides in matter. In artificial productions the moving principle is different from the material worked upon; but in nature the agent works within, being the most active and mobile part of the material itself. Thus this bold ecclesiastic, without incurring the censure of the church or the world, contrives to outstrip Mr. Darwin. The same cast of mind which caused him to detach the Creator from his universe led him also to detach the soul from the body, though to the body he ascribes an influence so large as to render the soul almost unnecessary. The aberrations of reason were in his view an affair of the material brain. Mental disease is brain-disease; but then the immortal reason sits apart, and cannot be touched by the disease. The errors of madness are errors of the instrument, not of the performer.

It may be more than a mere result of education, connecting itself probably with the deeper mental structure of the two men, that the idea of Gassendi, above enunciated, is substantially the same as that expressed by Professor Clerk Maxwell at the close of the very able lecture delivered by him at Bradford last year. According to both philosophers, the atoms, if I understand aright, are *prepared materials*, which, formed by the skill of the Highest, produce by their subsequent interaction all the phenomena of the material world. There seems to be this difference, however, between Gassendi and Maxwell. The one *postulates*, the other *infers* his first cause. In his "manufactured articles," as he calls the atoms, Professor Maxwell finds the basis of an induction, which enables him to scale philosophic heights considered inaccessible by Kant, and to take the logical step from the atoms to their Maker.

Accepting here the leadership of Kant, I doubt the legitimacy of Maxwell's logic; but it is impossible not to feel the ethic glow with which his lecture concludes. There is, moreover, a very noble strain of eloquence in his description of the stedfastness of the atoms:—"Natural causes, as we know, are at work, which tend to modify, if they do not at length destroy, all the arrangements and dimensions of the earth and the whole solar system. But though in the course of ages catastrophes have occurred and may yet occur in the heavens, though ancient systems may be dissolved and new systems evolved out of their ruins, the molecules out of which these systems are built—the foundation stones of the material universe—remain unbroken and unworn."

The atomic doctrine, in whole or in part, was entertained by Bacon, Descartes, Hobbes, Locke, Newton, Boyle, and their successors, until the chemical law of multiple proportions enabled Dalton to confer upon it an entirely new significance. In our day there are secessions from the theory, but it still stands firm. Loschmidt, Stoney, and Sir William Thomson have sought to determine the sizes of the atoms, or rather to fix the limits between which their sizes lie; while only last year the discourses of Williamson and Maxwell illustrate the present hold of the doctrine upon the foremost scientific minds. In fact, it may be doubted whether, wanting this fundamental conception, a theory of the material universe is capable of scientific statement.

Ninety years subsequent to Gassendi the doctrine of bodily instruments, as it may be called, assumed immense importance in the hands of Bishop Butler, who, in his famous 'Analogy of Religion,' developed, from his own point of view, and with consummate sagacity, a similar idea. The Bishop still influences superior minds; and it will repay us to dwell for a moment on his views. He draws the sharpest distinction between our real selves and our bodily instruments. He does not, as far as I remember, use the word soul, possibly because the term was so hackneyed in his day as it had been for many generations previously. But he speaks of "living powers," "perceiving" or "percipient powers," "moving agents," "ourselves," in the same sense as we should employ the term soul. He dwells upon the fact that limbs may be removed, and mortal diseases assail the body, the mind, almost up to the moment of death, remaining clear. He refers to sleep and to swoon, where the "living powers" are suspended but not destroyed. He considers it quite as easy to conceive of existence out of our bodies as in them; that we may animate a succession of bodies, the dissolution of all of them having no more tendency to dissolve our real selves, or "deprive us of living faculties—the faculties of perception and action—than the dissolution of any foreign matter which we are capable of receiving impressions from, or making use of for the common occasions of life." This is the key of the Bishop's position: "our organized bodies are no more a part of ourselves than any other matter around us." In proof of this he calls attention to the use of glasses, which "prepare objects" for the "percipient power" exactly as the eye does. The eye itself is no more percipient than the glass, is quite as much the instrument of the true self, and also as foreign to the true self, as the glass is. "And if we see with our eyes only in the same manner as we do with glasses, the like may justly be concluded from analogy of all our senses."

Lucretius, as you are aware, reached a precisely opposite conclusion; and it certainly would be interesting, if not profitable, to us all, to hear what he would or could urge in opposition to the reasoning of the Bishop. As a brief discussion of the point will enable us to see the bearings of an important question, I will here permit a disciple of Lucretius to try the strength of the Bishop's position, and then allow the Bishop to retaliate, with the view of rolling back, if he can, the difficulty upon Lucretius.

The argument might proceed in this fashion:—

"Subjected to the test of mental presentation (*Vorstellung*) your views, most honoured prelate, would present to many minds a great, if not an insuperable difficulty. You speak of 'living powers,' 'percipient or perceiving powers,' and 'ourselves;' but can you form a mental picture of any one of these apart from the organism through which it is supposed to act? Test yourself honestly, and see whether you possess any faculty that would enable you to form such a conception. The true self has a local habitation in each of us; thus localized, must it not possess a form? If so, what form? Have you ever for a moment realized it? When a leg is amputated the body is divided into two parts; is the true self in both of them or in one? Thomas Aquinas might say in both; but not you, for you appeal to the consciousness associated with one of the two parts to prove that the other is foreign matter. Is consciousness, then, a necessary element of the true self? If so, what do you say to the case of the whole body being deprived of consciousness? If not, then on what grounds do you deny any portion of the true self to the severed limb? It seems very singular that, from the beginning to the end of your admirable book (and no one admires its sober strength more than I do), you never once mention the brain or

nervous system. You begin at one end of the body, and show that its parts may be removed without prejudice to the perceiving power. What if you begin at the other end, and remove, instead of the leg, the brain? The body, as before, is divided into two parts; but both are now in the same predicament, and neither can be appealed to to prove that the other is foreign matter. Or, instead of going so far as to remove the brain itself, let a certain portion of its bony covering be removed, and let a rhythmic series of pressures and relaxations of pressure be applied to the soft substance. At every pressure 'the faculties of perception and of action,' vanish; at every relaxation of pressure they are restored. Where, during the intervals of pressure, is the perceiving power? I once had the discharge of a large Leyden battery passed unexpectedly through me: I felt nothing, but was simply blotted out of conscious existence for a sensible interval. Where was my true self during that interval? Men who have recovered from lightning-stroke have been much longer in the same state; and indeed in cases of ordinary concussion of the brain, days may elapse during which no experience is registered in consciousness. Where is the man himself during the period of insensibility? You may say that I beg the question when I assume the man to have been unconscious, that he was really conscious all the time, and has simply forgotten what had occurred to him. In reply to this, I can only say that no one need shrink from the worst tortures that superstition ever invented if only so felt and so remembered. I do not think your theory of instruments goes at all to the bottom of the matter. A telegraph-operator has his instruments, by means of which he converses with the world; our bodies possess a nervous system, which plays a similar part between the perceiving power and external things. Cut the wires of the operator, break his battery, demagnetize his needle: by this means you certainly sever his connexion with the world; but inasmuch as these are real instruments, their destruction does not touch the man who uses them. The operator survives, *and he knows that he survives*. What is it, I would ask, in the human system that answers to this conscious survival of the operator when the battery of the brain is so disturbed as to produce insensibility, or when it is destroyed altogether?

"Another consideration, which you may consider slight, presses upon me with some force. The brain may change from health to disease, and through such a change the most exemplary man may be converted into a debauchee or a murderer. My very noble and approved good master had, as you know, threatenings of lewdness introduced into his brain by his jealous wife's philter; and sooner than permit himself to run even the risk of yielding to these base promptings he slew himself. How could the hand of Lucretius have been thus turned against himself if the real Lucretius remained as before? Can the brain or can it not act in this distempered way without the intervention of the immortal reason? If it can, then it is a prime mover which requires only healthy regulation to render it reasonably self-acting, and there is no apparent need of your immortal reason at all. If it cannot, then the immortal reason, by its mischievous activity in operating upon a broken instrument, must have the credit of committing every imaginable extravagance and crime. I think, if you will allow me to say so, that the gravest consequences are likely to flow from your estimate of the body. To regard the brain as you would a staff or an eyeglass—to shut your eyes to all its mystery, to the perfect correlation of its condition and our consciousness, to the fact that a slight excess or defect of blood in it produces the very swoon to which you refer, and that in relation to it our meat and drink and air and

exercise have a perfectly transcendental value and significance—to forget all this does, I think, open a way to innumerable errors in our habits of life, and may possibly in some cases initiate and foster that very disease, and consequent mental ruin, which a wiser appreciation of this mysterious organ would have avoided."

I can imagine the Bishop thoughtful after hearing this argument. He was not the man to allow anger to mingle with the consideration of a point of this kind. After due reflection, and having strengthened himself by that honest contemplation of the facts which was habitual with him, and which includes the desire to give even adverse facts their due weight, I can suppose the Bishop to proceed thus:—"You will remember that in the 'Analogy of Religion,' of which you have so kindly spoken, I did not profess to prove any thing absolutely, and that I over and over again acknowledged and insisted on the smallness of our knowledge, or rather the depth of our ignorance, as regards the whole system of the universe. My object was to show my deistical friends, who set forth so eloquently the beauty and beneficence of Nature and the Ruler thereof, while they had nothing but scorn for the so-called absurdities of the Christian scheme, that they were in no better condition than we were, and that, for every difficulty found upon our side, quite as great a difficulty was to be found upon theirs. I will now with your permission adopt a similar line of argument. You are a Lucretian, and from the combination and separation of insensate atoms deduce all terrestrial things, including organic forms and their phenomena. Let me tell you in the first instance how far I am prepared to go with you. I admit that you can build crystalline forms out of this play of molecular force; that the diamond, amethyst, and snow-star are truly wonderful structures which are thus produced. I will go further and acknowledge that even a tree or flower might in this way be organized. Nay, if you can show me an animal without sensation, I will concede to you that it also might be put together by the suitable play of molecular force.

"Thus far our way is clear, but now comes my difficulty. Your atoms are individually without sensation, much more are they without intelligence. May I ask you, then, to try your hand upon this problem. Take your dead hydrogen atoms, your dead oxygen atoms, your dead carbon atoms, your dead nitrogen atoms, your dead phosphorus atoms, and all the other atoms, dead as grains of shot, of which the brain is formed. Imagine them separate and sensationless; observe them running together and forming all imaginable combinations. This, as a purely mechanical process, is *seeable* by the mind. But can you see, or dream, or in any way imagine, how out of that mechanical act, and from these individually dead atoms, sensation, thought, and emotion are to arise? Are you likely to extract Homer out of the rattling of dice, or the Differential Calculus out of the clash of billiard-balls? I am not all bereft of this *Vorstellungs-Kraft* of which you speak, nor am I, like so many of my brethren, a mere vacuum as regards scientific knowledge. I can follow a particle of musk until it reaches the olfactory nerve; I can follow the waves of sound until their tremors reach the water of the labyrinth, and set the otoliths and Corti's fibres in motion; I can also visualize the waves of ether as they cross the eye and hit the retina. Nay more, I am able to pursue to the central organ the motion thus imparted at the periphery, and to see in idea the very molecules of the brain thrown into tremors. My insight is not baffled by these physical processes. What baffles and bewilders me—is the notion that from those physical tremors things so utterly incongruous with them as sensation, thought, and emotion

can be derived. You may say, or think, that this issue of consciousness from the clash of atoms is not more incongruous than the flash of light from the union of oxygen and hydrogen. But I beg to say that it is. For such incongruity as the flash possesses is that which I now force upon your attention. The flash is an affair of consciousness, the objective counterpart of which is a vibration. It is a flash only by your interpretation. *You* are the cause of the apparent incongruity; and *you* are the thing that puzzles me. I need not remind you that the great Leibnitz felt the difficulty which I feel, and that to get rid of this monstrous deduction of life from death he displaced your atoms by his monads, which were more or less perfect mirrors of the universe, and out of the summation and integration of which he supposed all the phenomena of life—sentient, intellectual, and emotional—to arise.

"Your difficulty, then, as I see you are ready to admit, is quite as great as mine. You cannot satisfy the human understanding in its demand for logical continuity between molecular processes and the phenomena of consciousness. This is a rock on which materialism must inevitably split whenever it pretends to be a complete philosophy of life. What is the moral, my Lucretian? You and I are not likely to indulge in ill-temper in the discussion of these great topics, where we see so much room for honest differences of opinion. But there are people of less wit, or more bigotry (I say it with humility) on both sides, who are ever ready to mingle anger and vituperation with such discussions. There are, for example, writers of note and influence at the present day who are not ashamed to assume the 'deep personal sin' of a great logician to be the cause of his unbelief in a theologic dogma. And there are others who hold that we, who cherish our noble Bible, wrought as it has been into the constitution of our forefathers, and by inheritance into us, must necessarily be hypocritical and insincere. Let us disavow and discountenance such people, cherishing the unswerving faith that what is good and true in both our arguments will be preserved for the benefit of humanity, while all that is bad or false will disappear."

I hold the Bishop's reasoning to be unanswerable, and his liberality to be worthy of imitation.

It is worth remarking that in one respect the Bishop was a product of his age. Long previous to his day the nature of the soul had been so favourite and general a topic of discussion, that, when the students of the Italian Universities wished to know the leanings of a new Professor, they at once requested him to lecture upon the soul. About the time of Bishop Butler the question was not only agitated but extended. It was seen by the clear-witted men who entered this arena that many of their best arguments applied equally to brutes and men. The Bishop's arguments were of this character. He saw it, admitted it, accepted the consequences, and boldly embraced the whole animal world in his scheme of immortality.

Bishop Butler accepted with unwavering trust the chronology of the Old Testament, describing it as "confirmed by the natural and civil history of the world, collected from common historians, from the state of the earth, and from the late inventions of arts and sciences." These words mark progress; and they must seem somewhat hoary to the Bishop's successors of to-day*.

* Only to some; for there are dignitaries who even now speak of the earth's rocky crust as so much building material prepared for man at the Creation. Surely it is time that his loose language should cease.

It is hardly necessary to inform you that since his time the domain of the naturalist has been immensely extended—the whole science of geology, with its astounding revelations regarding the life of the ancient earth, having been created. The rigidity of old conceptions has been relaxed, the public mind being rendered gradually tolerant of the idea that not for six thousand, nor for sixty thousand, nor for six thousand thousand thousand, but for æons embracing untold millions of years, this earth has been the theatre of life and death. The riddle of the rocks has been read by the geologist and palæontologist, from subcambrian depths to the deposits thickening over the sea-bottoms of to-day. And upon the leaves of that stone book are, as you know, stamped the characters, plainer and surer than those formed by the ink of history, which carry the mind back into abysses of past time compared with which the periods which satisfied Bishop Butler cease to have a visual angle.

The lode of discovery once struck, those petrified forms in which life was at one time active, increased to multitudes and demanded classification. They were grouped in genera, species, and varieties, according to the degree of similarity subsisting between them. Thus confusion was avoided, each object being found in the pigeon-hole appropriated to it and to its fellows of similar morphological or physiological character. The general fact soon became evident that none but the simplest forms of life lie lowest down, that as we climb higher among the superimposed strata more perfect forms appear. The change, however, from form to form was not continuous, but by steps—some small, some great. "A section," says Mr. Huxley, "a hundred feet thick will exhibit at different heights a dozen species of Ammonite, none of which passes beyond its particular zone of limestone, or clay, into the zone below it, or into that above it." In the presence of such facts it was not possible to avoid the question:—Have these forms, showing, though in broken stages and with many irregularities, this unmistakable general advance, been subjected to no continuous law of growth or variation? Had our education been purely scientific, or had it been sufficiently detached from influences which, however ennobling in another domain, have always proved hindrances and delusions when introduced as factors into the domain of physics, the scientific mind never could have swerved from the search for a law of growth, or allowed itself to accept the anthropomorphism which regarded each successive stratum as a kind of mechanic's bench for the manufacture of new species out of all relation to the old.

Biased, however, by their previous education, the great majority of naturalists invoked a special creative act to account for the appearance of each new group of organisms. Doubtless there were numbers who were clear-headed enough to see that this was no explanation at all, that in point of fact it was an attempt, by the introduction of a greater difficulty, to account for a less. But having nothing to offer in the way of explanation, they for the most part held their peace. Still the thoughts of reflecting men naturally and necessarily simmered round the question. De Maillet, a contemporary of Newton, has been brought into notice by Professor Huxley as one who "had a notion of the modifiability of living forms." In my frequent conversations with him, the late Sir Benjamin Brodie, a man of highly philosophic mind, often drew my attention to the fact that, as early as 1794, Charles Darwin's grandfather was the pioneer of Charles Darwin*. In 1801, and in subsequent years, the celebrated Lamarck, who produced so profound an impression on the public mind

* Zoonomia, vol. i. pp. 500–510.

through the vigorous exposition of his views by the author of the 'Vestiges of Creation,' endeavoured to show the development of species out of changes of habit and external condition. In 1813 Dr. Wells, the founder of our present theory of Dew, read before the Royal Society a paper in which, to use the words of Mr. Darwin, "he distinctly recognizes the principle of natural selection; and this is the first recognition that has been indicated." The thoroughness and skill with which Wells pursued his work, and the obvious independence of his character, rendered him long ago a favourite with me; and it gave me the liveliest pleasure to alight upon this additional testimony to his penetration. Professor Grant, Mr. Patrick Matthew, Von Buch, the author of the 'Vestiges,' D'Halloy, and others*, by the enunciation of opinions more or less clear and correct, showed that the question had been fermenting long prior to the year 1858, when Mr. Darwin and Mr. Wallace simultaneously but independently placed their closely concurrent views upon the subject before the Linnean Society.

These papers were followed in 1859 by the publication of the first edition of 'The Origin of Species.' All great things come slowly to the birth. Copernicus, as I informed you, pondered his great work for thirty-three years. Newton for nearly twenty years kept the idea of Gravitation before his mind; for twenty years also he dwelt upon his discovery of Fluxions, and doubtless would have continued to make it the object of his private thought had he not found that Leibnitz was upon his track. Darwin for two and twenty years pondered the problem of the origin of species, and doubtless he would have continued to do so had he not found Wallace upon his track†. A concentrated, but full and powerful epitome of his labours was the consequence. The book was by no means an easy one; and probably not one in every score of those who then attacked it had read its pages through, or were competent to grasp their significance if they had. I do not say this merely to discredit them; for there were in those days some really eminent scientific men, entirely raised above the heat of popular prejudice, willing to accept any conclusion that science had to offer, provided it was duly backed by fact and argument, and who entirely mistook Mr. Darwin's views. In fact the work needed an expounder; and it found one in Mr. Huxley. I know nothing more admirable in the way of scientific exposition than those early articles of his on the origin of species. He swept the curve of discussion through the really significant points of the subject, enriched his exposition with profound original remarks and reflections, often summing up in a single pithy sentence an argument which a less compact mind would have spread over pages. But there is one impression made by the book itself which no exposition of it, however luminous, can convey; and that is the impression of the vast amount of labour, both of observation and of thought, implied in its production. Let us glance at its principles.

It is conceded on all hands that what are called varieties are continually produced. The rule is probably without exception. No chick and no child is in all respects and particulars the counterpart of its brother and sister; and in such differences we have "variety" incipient. No naturalist could tell how far this variation could be carried; but the great mass of them held that never by any amount of internal or external change, nor by the mixture of both,

* In 1855 Mr. Herbert Spencer ('Principles of Psychology,' 2nd edit. vol. i. p. 465) expressed "the belief that life under all its forms has arisen by an unbroken evolution, and through the instrumentality of what are called natural causes."

† The behaviour of Mr. Wallace in relation to this subject has been dignified in the highest degree.

could the offspring of the same progenitor so far deviate from each other as to constitute different species. The function of the experimental philosopher is to combine the conditions of nature and to produce her results; and this was the method of Darwin*. He made himself acquainted with what could, without any manner of doubt, be done in the way of producing variation. He associated himself with pigeon-fanciers—bought, begged, kept, and observed every breed that he could obtain. Though derived from a common stock, the diversities of these pigeons were such that "a score of them might be chosen which, if shown to an ornithologist, and he were told that they were wild birds, would certainly be ranked by him as well-defined species." The simple principle which guides the pigeon-fancier, as it does the cattle-breeder, is the selection of some variety that strikes his fancy, and the propagation of this variety by inheritance. With his eye still directed to the particular appearance which he wishes to exaggerate, he selects it as it reappears in successive broods, and thus adds increment to increment until an astonishing amount of divergence from the parent type is effected. The breeder in this case does not produce the *elements* of the variation. He simply observes them, and by selection adds them together until the required result has been obtained. "No man," says Mr. Darwin, "would ever try to make a fantail till he saw a pigeon with a tail developed in some slight degree in an unusual manner, or a pouter until he saw a pigeon with a crop of unusual size." Thus nature gives the hint, man acts upon it, and by the law of inheritance exaggerates the deviation.

Having thus satisfied himself by indubitable facts that the organization of an animal or of a plant (for precisely the same treatment applies to plants) is to some extent plastic, he passes from variation under domestication to variation under nature. Hitherto we have dealt with the adding together of small changes by the conscious selection of man. Can Nature thus select? Mr. Darwin's answer is, "Assuredly she can." The number of living things produced is far in excess of the number that can be supported; hence at some period or other of their lives there must be a struggle for existence; and what is the infallible result? If one organism were a perfect copy of the other in regard to strength, skill, and agility, external conditions would decide. But this is not the case. Here we have the fact of variety offering itself to nature, as in the former instance it offered itself to man; and those varieties which are least competent to cope with surrounding conditions will infallibly give way to those that are most competent. To use a familiar proverb, the weakest comes to the wall. But the triumphant fraction again breeds to overproduction, transmitting the qualities which secured its maintenance, but transmitting them in different degrees. The struggle for food again supervenes, and those to whom the favourable quality has been transmitted in excess will assuredly triumph. It is easy to see that we have here the addition of increments favourable to the individual still more rigorously carried out than in the case of domestication; for not only are unfavourable specimens not selected by nature, but they are destroyed. This is what Mr. Darwin calls "Natural Selection," which "acts by the preservation and accumulation of small inherited modifications, each profitable to the preserved being." With this idea he interpenetrates and leavens the vast store of facts that he and others

* The first step only towards experimental demonstration has been taken. Experiments now begun might, a couple of centuries hence, furnish data of incalculable value, which ought to be supplied to the science of the future.

have collected. We cannot, without shutting our eyes through fear or prejudice, fail to see that Darwin is here dealing, not with imaginary, but with true causes; nor can we fail to discern what vast modifications may be produced by natural selection in periods sufficiently long. Each individual increment may resemble what mathematicians call a "differential" (a quantity indefinitely small); but definite and great changes may obviously be produced by the integration of these infinitesimal quantities through practically infinite time.

If Darwin, like Bruno, rejects the notion of creative power acting after human fashion, it certainly is not because he is unacquainted with the numberless exquisite adaptations on which this notion of a supernatural artificer has been founded. His book is a repository of the most startling facts of this description. Take the marvellous observation which he cites from Dr. Crüger, where a bucket with an aperture, serving as a spout, is formed in an orchid. Bees visit the flower: in eager search of material for their combs they push each other into the bucket, the drenched ones escaping from their involuntary bath by the spout. Here they rub their backs against the viscid stigma of the flower and obtain glue; then against the pollen-masses, which are thus stuck to the back of the bee and carried away. "When the bee, so provided, flies to another flower, or to the same flower a second time, and is pushed by its comrades into the bucket, and then crawls out by the passage, the pollen-mass upon its back necessarily comes first into contact with the viscid stigma," which takes up the pollen; and this is how that orchid is fertilized. Or take this other case of the *Catasetum*. "Bees visit these flowers in order to gnaw the labellum; in doing this they inevitably touch a long, tapering, sensitive projection. This, when touched, transmits a sensation or vibration to a certain membrane, which is instantly ruptured, setting free a spring, by which the pollen-mass is shot forth like an arrow in the right direction, and adheres by its viscid extremity to the back of the bee." In this way the fertilizing pollen is spread abroad.

It is the mind thus stored with the choicest materials of the teleologist that rejects teleology, seeking to refer these wonders to natural cases. They illustrate, according to him, the method of nature, not the "technic" of a man-like Artificer. The beauty of flowers is due to natural selection. Those that distinguish themselves by vividly contrasting colours from the surrounding green leaves are most readily seen, most frequently visited by insects, most often fertilized, and hence most favoured by natural selection. Coloured berries also readily attract the attention of birds and beasts, which feed upon them, spread their manured seeds abroad, thus giving trees and shrubs possessing such berries a greater chance in the struggle for existence.

With profound analytic and synthetic skill, Mr. Darwin investigates the cell-making instinct of the hive-bee. His method of dealing with it is representative. He falls back from the more perfectly to the less perfectly developed instinct—from the hive-bee to the humble bee, which uses its own cocoon as a comb, and to classes of bees of intermediate skill, endeavouring to show how the passage might be gradually made from the lowest to the highest. The saving of wax is the most important point in the economy of bees. Twelve to fifteen pounds of dry sugar are said to be needed for the secretion of a single pound of wax. The quantities of nectar necessary for the wax must therefore be vast; and every improvement of constructive instinct which results in the saving of wax is a direct profit to the insect's life. The time that would otherwise be devoted to the making of wax is now devoted to the gathering and storing of honey for winter food.

He passes from the humble bee with its rude cells, through the Melipona with its more artistic cells, to the hive-bee with its astonishing architecture, The bees place themselves at equal distances apart upon the wax, sweep and excavate equal spheres round the selected points. The spheres intersect, and the planes of intersection are built up with thin laminæ. Hexagonal cells are thus formed. This mode of treating such questions is, as I have said, representative. He habitually retires from the more perfect and complex, to the less perfect and simple, and carries you with him through stages of *perfecting,* adds increment to increment of infinitesimal change, and in this way gradually breaks down your reluctance to admit that the exquisite climax of the whole could be a result of natural selection.

Mr. Darwin shirks no difficulty; and, saturated as the subject was with his own thought, he must have known, better than his critics, the weakness as well as the strength of his theory. This of course would be of little avail were his object a temporary dialectic victory instead of the establishment of a truth which he means to be everlasting. But he takes no pains to disguise the weakness he has discerned; nay, he takes every pains to bring it into the strongest light. His vast resources enable him to cope with objections started by himself and others, so as to leave the final impression upon the reader's mind that, if they be not completely answered, they certainly are not fatal. Their negative force being thus destroyed, you are free to be influenced by the vast positive mass of evidence he is able to bring before you. This largeness of knowledge and readiness of resource render Mr. Darwin the most terrible of antagonists. Accomplished naturalists have levelled heavy and sustained criticisms against him—not always with the view of fairly weighing his theory, but with the express intention of exposing its weak points only. This does not irritate him. He treats every objection with a soberness and thoroughness which even Bishop Butler might be proud to imitate, surrounding each fact with its appropriate detail, placing it in its proper relations, and usually giving it a significance which, as long as it was kept isolated, failed to appear. This is done without a trace of ill-temper. He moves over the subject with the passionless strength of a glacier; and the grinding of the rocks is not always without a counterpart in the logical pulverization of the objector. But though in handling this mighty theme all passion has been stilled, there is an emotion of the intellect incident to the discernment of new truth which often colours and warms the pages of Mr. Darwin. His success has been great; and this implies not only the solidity of his work, but the preparedness of the public mind for such a revelation. On this head a remark of Agassiz impressed me more than any thing else. Sprung from a race of theologians, this celebrated man combated to the last the theory of natural selection. One of the many times I had the pleasure of meeting him in the United States was at Mr. Winthrop's beautiful residence at Brookline, near Boston. Rising from luncheon, we all halted as if by a common impulse in front of a window, and continued there a discussion which had been started at table. The maple was in its autumn glory; and the exquisite beauty of the scene outside seemed, in my case, to interpenetrate without disturbance the intellectual action. Earnestly, almost sadly, Agassiz turned, and said to the gentlemen standing round, "I confess that I was not prepared to see this theory received as it has been by the best intellects of our time. Its success is greater than I could have thought possible."

In our day grand generalizations have been reached. The theory of the origin of species is but one of them. Another, of still wider grasp and more

radical significance, is the doctrine of the Conservation of Energy, the ultimate philosophical issues of which are as yet but dimly seen—that doctrine which "binds nature fast in fate" to an extent not hitherto recognized, exacting from every antecedent its equivalent consequent, from every consequent its equivalent antecedent, and bringing vital as well as physical phenomena under the dominion of that law of causal connexion which, so far as the human understanding has yet pierced, asserts itself everywhere in nature. Long in advance of all definite experiment upon the subject, the constancy and indestructibility of matter had been affirmed; and all subsequent experience justified the affirmation. Later researches extended the attribute of indestructibility to force. This idea, applied in the first instance to inorganic, rapidly embraced organic nature. The vegetable world, though drawing almost all its nutriment from invisible sources, was proved incompetent to generate anew either matter or force. Its matter is for the most part transmuted gas; its force transformed solar force. The animal world was proved to be equally uncreative, all its motive energies being referred to the combustion of its food. The activity of each animal as a whole was proved to be the transferred activity of its molecules. The muscles were shown to be stores of mechanical force, potential until unlocked by the nerves, and then resulting in muscular contractions. The speed at which messages fly to and fro along the nerves was determined, and found to be, not as had been previously supposed, equal to that of light or electricity, but less than the speed of a flying eagle.

This was the work of the physicist: then came the conquests of the comparative anatomist and physiologist, revealing the structure of every animal, and the function of every organ in the whole biological series, from the lowest zoophyte up to man. The nervous system had been made the object of profound and continued study, the wonderful and, at bottom, entirely mysterious controlling power which it exercises over the whole organism, physical and mental, being recognized more and more. Thought could not be kept back from a subject so profoundly suggestive. Besides the physical life dealt with by Mr. Darwin, there is a psychical life presenting similar gradations, and asking equally for a solution. How are the different grades and orders of Mind to be accounted for? What is the principle of growth of that mysterious power which on our planet culminates in Reason? These are questions which, though not thrusting themselves so forcibly upon the attention of the general public, had not only occupied many reflecting minds, but had been formally broached by one of them before the 'Origin of Species' appeared.

With the mass of materials furnished by the physicist and physiologist in his hands, Mr. Herbert Spencer, twenty years ago, sought to graft upon this basis a system of psychology; and two years ago a second and greatly amplified edition of his work appeared. Those who have occupied themselves with the beautiful experiments of Plateau will remember that when two spherules of olive-oil suspended in a mixture of alcohol and water of the same density as the oil, are brought together, they do not immediately unite. Something like a pellicle appears to be formed around the drops, the rupture of which is immediately followed by the coalescence of the globules into one. There are organisms whose vital actions are almost as purely physical as that of these drops of oil. They come into contact and fuse themselves thus together. From such organisms to others a shade higher, and from these to others a shade higher still, and on through an ever ascending series, Mr. Spencer conducts his argument. There are two

obvious factors to be here taken into account—the creature and the medium in which it lives, or, as it is often expressed, the organism and its environment. Mr. Spencer's fundamental principle is, that between these two factors there is incessant interaction. The organism is played upon by the environment, and is modified to meet the requirements of the environment. Life he defines to be "a continuous adjustment of internal relations to external relations."

In the lowest organisms we have a kind of tactual sense diffused over the entire body; then, through impressions from without and their corresponding adjustments, special portions of the surface become more responsive to stimuli than others. The senses are nascent, the basis of all of them being that simple tactual sense which the sage Democritus recognized 2300 years ago as their common progenitor. The action of light, in the first instance, appears to be a mere disturbance of the chemical processes in the animal organism, similar to that which occurs in the leaves of plants. By degrees the action becomes localized in a few pigment-cells, more sensitive to light than the surrounding tissue. The eye is here incipient. At first it is merely capable of revealing differences of light and shade produced by bodies close at hand. Followed as the interception of the light is in almost all cases by the contact of the closely adjacent opaque body, sight in this condition becomes a kind of "anticipatory touch." The adjustment continues; a slight bulging out of the epidermis over the pigment-granules supervenes. A lens is incipient, and, through the operation of infinite adjustments, at length reaches the perfection that it displays in the hawk and eagle. So of the other senses; they are special differentiations of a tissue which was originally vaguely sensitive all over.

With the development of the senses the adjustments between the organism and its environment gradually extend in *space*, a multiplication of experiences and a corresponding modification of conduct being the result. The adjustments also extend in *time*, covering continually greater intervals. Along with this extension in space and time the adjustments also increase in speciality and complexity, passing through the various grades of brute life, and prolonging themselves into the domain of reason. Very striking are Mr. Spencer's remarks regarding the influence of the sense of touch upon the development of intelligence. This is, so to say, the mother-tongue of all the senses, into which they must be translated to be of service to the organism. Hence its importance. The parrot is the most intelligent of birds, and its tactual power is also greatest. From this sense it gets knowledge unattainable by birds which cannot employ their feet as hands. The elephant is the most sagacious of quadrupeds—its tactual range and skill, and the consequent multiplication of experiences, which it owes to its wonderfully adaptable trunk, being the basis of its sagacity. Feline animals, for a similar cause, are more sagacious than hoofed animals,—atonement being to some extent made, in the case of the horse, by the possession of sensitive prehensile lips. In the *Primates* the evolution of intellect and the evolution of tactual appendages go hand in hand. In the most intelligent anthropoid apes we find the tactual range and delicacy greatly augmented, new avenues of knowledge being thus opened to the animal. Man crowns the edifice here, not only in virtue of his own manipulatory power, but through the enormous extension of his range of experience, by the invention of instruments of precision, which serve as supplemental senses and supplemental limbs. The reciprocal action of these is finely described and illustrated. That chastened intellectual emotion to which I have referred in connexion with Mr. Darwin is not absent in Mr.

Spencer. His illustrations possess at times exceeding vividness and force; and from his style on such occasions it is to be inferred that the ganglia of this Apostle of the Understanding are sometimes the seat of a nascent poetic thrill.

It is a fact of supreme importance that actions the performance of which at first requires even painful effort and deliberation, may by habit be rendered automatic. Witness the slow learning of its letters by a child, and the subsequent facility of reading in a man, when each group of letters which forms a word is instantly, and without effort, fused to a single perception. Instance the billiard-player, whose muscles of hand and eye, when he reaches the perfection of his art, are unconsciously coordinated. Instance the musician, who, by practice, is enabled to fuse a multitude of arrangements, auditory, tactual and muscular, into a process of automatic manipulation. Combining such facts with the doctrine of hereditary transmission, we reach a theory of Instinct. A chick, after coming out of the egg, balances itself correctly, runs about, picks up food, thus showing that it possesses a power of directing its movements to definite ends. How did the chick learn this very complex coordination of eye, muscles, and beak? It has not been individually taught; its personal experience is *nil*; but it has the benefit of ancestral experience. In its inherited organization are registered all the powers which it displays at birth. So also as regards the instinct of the hive-bee, already referred to. The distance at which the insects stand apart when they sweep their hemispheres and build their cells is "organically remembered." Man also carries with him the physical texture of his ancestry, as well as the inherited intellect bound up with it. The defects of intelligence during infancy and youth are probably less due to a lack of individual experience than to the fact that in early life the cerebral organization is still incomplete. The period necessary for completion varies with the race, and with the individual. As a round shot outstrips a rifled one on quitting the muzzle of the gun, so the lower race in childhood may outstrip the higher. But the higher eventually overtakes the lower, and surpasses it in range. As regards individuals, we do not always find the precocity of youth prolonged to mental power in maturity; while the dulness of boyhood is sometimes strikingly contrasted with the intellectual energy of after years. Newton, when a boy, was weakly, and he showed no particular aptitude at school; but in his eighteenth year he went to Cambridge, and soon afterwards astonished his teachers by his power of dealing with geometrical problems. During his quiet youth his brain was slowly preparing itself to be the organ of those energies which he subsequently displayed.

By myriad blows (to use a Lucretian phrase) the image and superscription of the external world are stamped as states of consciousness upon the organism, the depth of the impression depending upon the number of the blows. When two or more phenomena occur in the environment invariably together, they are stamped to the same depth or to the same relief, and indissolubly connected. And here we come to the threshold of a great question. Seeing that he could in no way rid himself of the consciousness of Space and Time, Kant assumed them to be necessary "forms of intuition," the moulds and shapes into which our intuitions are thrown, belonging to ourselves solely and without objective existence. With unexpected power and success Mr. Spencer brings the hereditary experience theory, as he holds it, to bear upon this question. "If there exist certain external relations which are experienced by all organisms at all instants of their waking lives—relations which are absolutely constant and universal—there will be established an-

swering internal relations that are absolutely constant and universal. Such relations we have in those of Space and Time. As the substratum of all other relations of the Non-Ego, they must be responded to by conceptions that are the substrata of all other relations in the Ego. Being the constant and infinitely repeated elements of thought, they must become the automatic elements of thought—the elements of thought which it is impossible to get rid of—the 'forms of intuition.'"

Throughout this application and extension of the "Law of Inseparable Association," Mr. Spencer stands upon his own ground, invoking instead of the experiences of the individual the registered experiences of the race. His overthrow of the restriction of experience to the individual is, I think, complete. That restriction ignores the power of organizing experience furnished at the outset to each individual; it ignores the different degrees of this power possessed by different races and by different individuals of the same race. Were there not in the human brain a potency antecedent to all experience, a dog or cat ought to be as capable of education as a man. These predetermined internal relations are independent of the experiences of the individual. The human brain is the "organized register of infinitely numerous experiences received during the evolution of life, or rather during the evolution of that series of organisms through which the human organism has been reached. The effects of the most uniform and frequent of these experiences have been successively bequeathed, principal and interest, and have slowly mounted to that high intelligence which lies latent in the brain of the infant. Thus it happens that the European inherits from twenty to thirty cubic inches more of brain than the Papuan. Thus it happens that faculties, as of music, which scarcely exist in some inferior races, become congenital in superior ones. Thus it happens that out of savages unable to count up to the number of their fingers, and speaking a language containing only nouns and verbs, arise at length our Newtons and Shakespeares."

At the outset of this Address it was stated that physical theories which lie beyond experience are derived by a process of abstraction from experience. It is instructive to note from this point of view the successive introduction of new conceptions. The idea of the attraction of gravitation was preceded by the observation of the attraction of iron by a magnet, and of light bodies by rubbed amber. The polarity of magnetism and electricity appealed to the senses; and thus became the substratum of the conception that atoms and molecules are endowed with definite, attractive and repellent poles, by the play of which definite forms of crystalline architecture are produced. Thus molecular force becomes *structural*. It required no great boldness of thought to extend its play into organic nature, and to recognize in molecular force the agency by which both plants and animals are built up. In this way out of experience arise conceptions which are wholly ultra-experiential. None of the atomists of antiquity had any notion of this play of molecular polar force, but they had experience of gravity as manifested by falling bodies. Abstracting from this, they permitted their atoms to fall eternally through empty space; Democritus assumed that the larger atoms moved more rapidly than the smaller ones, which they therefore could overtake, and with which they could combine. Epicurus, holding that empty space could offer no resistance to motion, ascribed to all the atoms the same velocity; but he seems to have overlooked the consequence that under such circumstances the atoms could never combine. Lucretius cut the knot by quitting the domain of physics altogether, and causing the atoms to move together by a kind of volition.

Was the instinct utterly at fault which caused Lucretius thus to swerve

from his own principles? Diminishing gradually the number of progenitors, Mr. Darwin comes at length to one "primordial form;" but he does not say, as far as I remember, how he supposes this form to have been introduced. He quotes with satisfaction the words of a celebrated author and divine who had "gradually learnt to see that it is just as noble a conception of the Deity to believe He created a few original forms, capable of self-development into other and needful forms, as to believe that He required a fresh act of creation to supply the voids caused by the action of His laws." What Mr. Darwin thinks of this view of the introduction of life I do not know. But the anthropomorphism, which it seemed his object to set aside, is as firmly associated with the creation of a few forms as with the creation of a multitude. We need clearness and thoroughness here. Two courses and two only are possible. Either let us open our doors freely to the conception of creative acts, or, abandoning them, let us radically change our notions of Matter. If we look at matter as pictured by Democritus, and as defined for generations in our scientific text-books, the notion of any form of life whatever coming out of it is utterly unimaginable. The argument placed in the mouth of Bishop Butler suffices, in my opinion, to crush all such materialism as this. But those who framed these definitions of matter were not biologists but mathematicians, whose labours referred only to such accidents and properties of matter as could be expressed in their formulæ. The very intentness with which they pursued mechanical science turned their thoughts aside from the science of life. May not their imperfect definitions be the real cause of our present dread? Let us reverently, but honestly, look the question in the face. Divorced from matter, where is life to be found? Whatever our *faith* may say, our *knowledge* shows them to be indissolubly joined. Every meal we eat, and every cup we drink, illustrates the mysterious control of Mind by Matter.

Trace the line of life backwards, and see it approaching more and more to what we call the purely physical condition. We come at length to those organisms which I have compared to drops of oil suspended in a mixture of alcohol and water. We reach the *protogenes* of Haeckel, in which we have "a type distinguishable from a fragment of albumen only by its finely granular character." Can we pause here? We break a magnet and find two poles in each of its fragments. We continue the process of breaking, but, however small the parts, each carries with it, though enfeebled, the polarity of the whole. And when we can break no longer, we prolong the intellectual vision to the polar molecules. Are we not urged to do *something* similar in the case of life? Is there not a temptation to close to some extent with Lucretius, when he affirms that "nature is seen to do all things spontaneously of herself without the meddling of the gods"? or with Bruno, when he declares that Matter is not "that mere empty *capacity* which philosophers have pictured her to be, but the universal mother who brings forth all things as the fruit of her own womb"? Believing, as I do, in the continuity of Nature, I cannot stop abruptly where our microscopes cease to be of use. Here the vision of the mind authoritatively supplements the vision of the eye. By an intellectual necessity I cross the boundary of the experimental evidence, and discern in that Matter which we, in our ignorance of its latent powers, and notwithstanding our professed reverence for its Creator, have hitherto covered with opprobrium, the promise and potency of all terrestrial Life.

If you ask me whether there exists the least evidence to prove that any form of life can be developed out of matter, without demonstrable antecedent life, my reply is that evidence considered perfectly conclusive by many has

been adduced; and that were some of us who have pondered this question to follow a very common example, and accept testimony because it falls in with our belief, we also should eagerly close with the evidence referred to. But there is in the true man of science a wish stronger than the wish to have his beliefs upheld; namely, the wish to have them true. And this stronger wish causes him to reject the most plausible support if he has reason to suspect that it is vitiated by error. Those to whom I refer as having studied this question, believing the evidence offered in favour of "spontaneous generation" to be thus vitiated, cannot accept it. They know full well that the chemist now prepares from inorganic matter a vast array of substances which were some time ago regarded as the sole products of vitality. They are intimately acquainted with the structural power of matter as evidenced in the phenomena of crystallization. They can justify scientifically their *belief* in its potency, under the proper conditions, to produce organisms. But in reply to your question they will frankly admit their inability to point to any satisfactory experimental proof that life can be developed save from demonstrable antecedent life. As already indicated, they draw the line from the highest organisms through lower ones down to the lowest, and it is the prolongation of this line by the intellect beyond the range of the senses that leads them to the conclusion which Bruno so boldly enunciated*.

The "materialism" here professed may be vastly different from what you suppose, and I therefore crave your gracious patience to the end. "The question of an external world," says Mr. J. S. Mill, "is the great battle-ground of metaphysics"†. Mr. Mill himself reduces external phenomena to "possibilities of sensation." Kant, as we have seen, made time and space "forms" of our own intuitions. Fichte, having first by the inexorable logic of his understanding proved himself to be a mere link in that chain of eternal causation which holds so rigidly in nature, violently broke the chain by making nature, and all that it inherits, an apparition of his own mind‡. And it is by no means easy to combat such notions. For when I say I see you, and that I have not the least doubt about it, the reply is, that what I am really conscious of is an affection of my own retina. And if I urge that I can check my sight of you by touching you, the retort would be that I am equally transgressing the limits of fact; for what I am really conscious of is, not that you are there, but that the nerves of my hand have undergone a change. All we hear, and see, and touch, and taste, and smell, are, it would be urged, mere variations of our own condition, beyond which, even to the extent of a hair's breadth, we cannot go. That any thing answering to our impressions exists outside of ourselves is not a *fact*, but an *inference*, to which all validity would be denied by an idealist like Berkeley, or by a sceptic like Hume. Mr. Spencer takes another line. With him, as with the uneducated man, there is no doubt or question as to the existence of an external world. But he differs from the uneducated, who think that the world really *is* what consciousness represents it to be. Our states of consciousness are mere *symbols* of an outside entity which produces them and determines the order of their succession, but the real nature of which we can never know§. In

* Bruno was a "Pantheist," not an "Atheist" or a "Materialist."

† Examination of Hamilton, p. 154.

‡ Bestimmung des Menschen.

§ In a paper, at once popular and profound, entitled "Recent Progress in the Theory of Vision," contained in the volume of Lectures by Helmholtz, published by Longmans, this symbolism of our states of consciousness is also dwelt upon. The impressions of sense are the mere *signs* of external things. In this paper Helmholtz contends strongly against the view that the consciousness of space is inborn; and he evidently doubts the power

fact the whole process of evolution is the manifestation of a Power absolutely inscrutable to the intellect of man. As little in our day as in the days of Job can man by searching find this Power out. Considered fundamentally, then, it is by the operation of an insoluble mystery that life on earth is evolved, species differentiated, and mind unfolded from their prepotent elements in the immeasurable past. There is, you will observe, no very rank materialism here.

The strength of the doctrine of evolution consists, not in an experimental demonstration (for the subject is hardly accessible to this mode of proof), but in its general harmony with scientific thought. From contrast, moreover, it derives enormous relative strength. On the one side we have a theory (if it could with any propriety be so called) derived, as were the theories referred to at the beginning of this Address, not from the study of nature, but from the observation of men—a theory which converts the Power whose garment is seen in the visible universe into an Artificer, fashioned after the human model, and acting by broken efforts as man is seen to act. On the other side we have the conception that all we see around us, and all we feel within us—the phenomena of physical nature as well as those of the human mind—have their unsearchable roots in a cosmical life, if I dare apply the term, an infinitesimal span of which is offered to the investigation of man. And even this span is only knowable in part. We can trace the development of a nervous system, and correlate with it the parallel phenomena of sensation and thought. We see with undoubting certainty that they go hand in hand. But we try to soar in a vacuum the moment we seek to comprehend the connexion between them. An Archimedean fulcrum is here required which the human mind cannot command; and the effort to solve the problem, to borrow a comparison from an illustrious friend of mine, is like the effort of a man trying to lift himself by his own waistband. All that has been here said is to be taken in connexion with this fundamental truth. When "nascent senses" are spoken of, when "the differentiation of a tissue at first vaguely sensitive all over" is spoken of, and when these processes are associated with "the modification of an organism by its environment," the same parallelism, without contact, or even approach to contact, is implied. Man the *object* is separated by an impassable gulf from man the *subject*. There is no motor energy in intellect to carry it without logical rupture from the one to the other.

Further, the doctrine of evolution derives man, in his totality, from the interaction of organism and environment through countless ages past. The Human Understanding, for example—that faculty which Mr. Spencer has turned so skilfully round upon its own antecedents—is itself a result of the play between organism and environment through cosmic ranges of time. Never surely did prescription plead so irresistible a claim. But then it comes to pass that, over and above his understanding, there are many other things appertaining to man whose prescriptive rights are quite as strong as those of the understanding itself. It is a result, for example, of the play of organism and environment that sugar is sweet and that aloes are bitter, that the smell of

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of the chick to pick up grains of corn without preliminary lessons. On this point, he says, further experiments are needed. Such experiments have been since made by Mr. Spalding, aided, I believe, in some of his observations by the accomplished and deeply lamented Lady Amberly; and they seem to prove conclusively that the chick does not need a single moment's tuition to enable it to stand, run, govern the muscles of its eyes, and peck. Helmholtz, however, is contending against the notion of preestablished harmony; and I am not aware of his views as to the organization of experiences of race or breed.

henbane differs from the perfume of a rose. Such facts of consciousness (for which, by the way, no adequate reason has yet been rendered) are quite as old as the understanding; and many other things can boast an equally ancient origin. Mr. Spencer at one place refers to that most powerful of passions—the amatory passion—as one which, when it first occurs, is antecedent to all relative experience whatever; and we may pass its claim as being at least as ancient and valid as that of the understanding. Then there are such things woven into the texture of man as the feeling of Awe, Reverence, Wonder—and not alone the sexual love just referred to, but the love of the beautiful, physical, and moral, in Nature, Poetry, and Art. There is also that deep-set feeling which, since the earliest dawn of history, and probably for ages prior to all history, incorporated itself in the Religions of the world. You who have escaped from these religions into the high-and-dry light of the intellect may deride them; but in so doing you deride accidents of form merely, and fail to touch the immovable basis of the religious sentiment in the nature of man. To yield this sentiment reasonable satisfaction is the problem of problems at the present hour. And grotesque in relation to scientific culture as many of the religions of the world have been and are—dangerous, nay, destructive, to the dearest privileges of freemen as some of them undoubtedly have been, and would, if they could, be again—it will be wise to recognize them as the forms of a force, mischievous, if permitted to intrude on the region of objective *knowledge*, over which it holds no command, but capable of adding in the region of *poetry* and *emotion*, inward completeness and dignity to man.

Feeling, I say again, dates from as old an origin and as high a source as intelligence, and it equally demands its range of play. The wise teacher of humanity will recognize the necessity of meeting this demand rather than of resisting it on account of errors and absurdities of form. What we should resist, at all hazards, is the attempt made in the past, and now repeated, to found upon this elemental bias of man's nature a system which should exercise despotic sway over his intellect. I have no fears as to such a consummation. Science has already to some extent leavened the world: it will leaven it more and more; and I should look upon the light of science breaking in upon the minds of the youth of Ireland, and strengthening gradually to the perfect day, as a surer check to any intellectual or spiritual tyranny which now threatens this island, than the laws of princes or the swords of emperors. We fought and won our battle even in the Middle Ages: should we doubt the issue of a conflict with our broken foe?

The impregnable position of science may be described in a few words. We claim, and we shall wrest, from theology the entire domain of cosmological theory. All schemes and systems which thus infringe upon the domain of science must, *in so far as they do this*, submit to its control, and relinquish all thought of controlling it. Acting otherwise proved disastrous in the past, and it is simply fatuous to-day. Every system which would escape the fate of an organism too rigid to adjust itself to its environment, must be plastic to the extent that the growth of knowledge demands. When this truth has been thoroughly taken in, rigidity will be relaxed, exclusiveness diminished, things now deemed essential will be dropped, and elements now rejected will be assimilated. The lifting of the life is the essential point; and as long as dogmatism, fanaticism, and intolerance are kept out, various modes of leverage may be employed to raise life to a higher level.

Science itself not unfrequently derives motive power from an ultra-scientific source. Some of its greatest discoveries have been made under the

stimulus of a non-scientific ideal. This was the case among the ancients, and it has been so amongst ourselves. Mayer, Joule, and Colding, whose names are associated with the greatest of modern generalizations, were thus influenced. With his usual insight, Lange at one place remarks, that "it is not always the objectively correct and intelligible that helps man most, or leads most quickly to the fullest and truest knowledge. As the sliding body upon the brachystochrone reaches its end sooner than by the straighter road of the inclined plane, so through the swing of the ideal we often arrive at the naked truth more rapidly than by the more direct processes of the understanding." Whewell speaks of enthusiasm of temper as a hindrance to science; but he means the enthusiasm of weak heads. There is a strong and resolute enthusiasm in which science finds an ally; and it is to the lowering of this fire, rather than to the diminution of intellectual insight, that the lessening productiveness of men of science in their mature years is to be ascribed. Mr. Buckle sought to detach intellectual achievement from moral force. He gravely erred; for without moral force to whip it into action, the achievements of the intellect would be poor indeed.

It has been said that science divorces itself from literature; but the statement, like so many others, arises from lack of knowledge. A glance at the less technical writings of its leaders—of its Helmholtz, its Huxley, and its Du Bois-Reymond—would show what breadth of literary culture they command. Where among modern writers can you find their superiors in clearness and vigour of literary style? Science desires not isolation, but freely combines with every effort towards the bettering of man's estate. Single-handed, and supported not by outward sympathy, but by inward force, it has built at least one great wing of the many-mansioned home which man in his totality demands. And if rough walls and protruding rafter-ends indicate that on one side the edifice is still incomplete, it is only by wise combination of the parts required with those already irrevocably built that we can hope for completeness. There is no necessary incongruity between what has been accomplished and what remains to be done. The moral glow of Socrates, which we all feel by ignition, has in it nothing incompatible with the physics of Anaxagoras which he so much scorned, but which he would hardly scorn to-day. And here I am reminded of one amongst us, hoary, but still strong, whose prophet-voice some thirty years ago, far more than any other of this age, unlocked whatever of life and nobleness lay latent in its most gifted minds—one fit to stand beside Socrates or the Maccabean Eleazar, and to dare and suffer all that they suffered and dared—fit, as he once said of Fichte, "to have been the teacher of the Stoa, and to have discoursed of Beauty and Virtue in the groves of Academe." With a capacity to grasp physical principles which his friend Goethe did not possess, and which even total lack of exercise has not been able to reduce to atrophy, it is the world's loss that he, in the vigour of his years, did not open his mind and sympathies to science, and make its conclusions a portion of his message to mankind. Marvellously endowed as he was—equally equipped on the side of the Heart and of the Understanding—he might have done much towards teaching us how to reconcile the claims of both, and to enable them in coming times to dwell together in unity of spirit and in the bond of peace.

And now the end is come. With more time, or greater strength and knowledge, what has been here said might have been better said, while worthy matters here omitted might have received fit expression. But there would have been no material deviation from the views set forth. As regards myself, they are not the growth of a day; and as regards you, I thought you

ought to know the environment which, with or without your consent, is rapidly surrounding you, and in relation to which some adjustment on your part may be necessary. A hint of Hamlet's, however, teaches us all how the troubles of common life may be ended; and it is perfectly possible for you and me to purchase intellectual peace at the price of intellectual death. The world is not without refuges of this description; nor is it wanting in persons who seek their shelter and try to persuade others to do the same. The unstable and the weak have yielded, and will yield to this persuasion, and they to whom repose is sweeter than the truth. But I would exhort you to refuse the offered shelter, and to scorn the base repose—to accept, if the choice be forced upon you, commotion before stagnation, the leap of the torrent before the stillness of the swamp. In the course of this address I have touched on debatable questions, and led you over what will be deemed dangerous ground—and this partly with the view of telling you that as regards these questions science claims unrestricted right of search. It is not to the point to say that the views of Lucretius and Bruno, of Darwin and Spencer, may be wrong. Here I should agree with you, deeming it indeed certain that these views will undergo modification. But the point is, that, whether right or wrong, we claim the right to discuss them. For science, however, no exclusive claim is here made; you are not urged to erect it into an idol. Inexorable advance of man's understanding in the path of knowledge, and those unquenchable claims of his moral and emotional nature which the understanding can never satisfy, are here equally set forth The world embraces not only a Newton, but a Shakspeare—not only a Boyle, but a Raphael—not only a Kant, but a Beethoven—not only a Darwin, but a Carlyle. Not in each of these, but in all, is human nature whole. They are not opposed, but supplementary—not mutually exclusive, but reconcilable. And if, unsatisfied with them all, the human mind, with the yearning of a pilgrim for his distant home, will still turn to the Mystery from which it has emerged, seeking so to fashion it as to give unity to thought and faith, so long as this is done, not only without intolerance or bigotry of any kind, but with the enlightened recognition that ultimate fixity of conception is here unattainable, and that each succeeding age must be held free to fashion the mystery in accordance with its own needs—then, casting aside all the restrictions of Materialism, I would affirm this to be a field for the noblest exercise of what, in contrast with the *knowing* faculties, may be called the *creative* faculties of man. Here, however, I touch a theme too great for me to handle, but which will assuredly be handled by the loftiest minds when you and I, like streaks of morning cloud, shall have melted into the infinite azure of the past.

REPORTS

ON

THE STATE OF SCIENCE.

Tenth Report of the Committee for Exploring Kent's Cavern, Devonshire, the Committee consisting of Sir Charles Lyell, *Bart., F.R.S.,* Sir John Lubbock, *Bart., F.R.S.,* John Evans, *F.R.S.,* Edward Vivian, *M.A.,* George Busk, *F.R.S.,* William Boyd Dawkins, *F.R.S.,* William Ayshford Sanford, *F.G.S.,* John Edward Lea, *F.G.S., and* William Pengelly, *F.R.S.* (*Reporter*).

Before entering on this, their Tenth Report, the Committee desire to express their deep sense of the great loss they have sustained in the decease of Professor Phillips. No member was more regular in his attendance at the meetings of the Committee, or felt a livelier interest in the investigation with which they are charged. On March 18, 1874 (little more than a month before his lamented death), though suffering from a severe cold, he visited the Cavern, when he carefully inspected those branches of it which have been explored, and expressed his admiration of the clearness and importance of the evidence bearing on the question of human antiquity which had been obtained.

The Ninth Report, presented to the Association at the Bradford Meeting, brought the work up to the end of August 1873, when the Committee were engaged in the Exploration of the "Long Arcade." From that time the investigation has been pursued, without intermission, in the manner uniformly observed from the commencement, and which was described in detail in the First Report (1865). The work has been performed in the most satisfactory manner by the workmen mentioned last year (George Smerdon and John Clinnick); the Superintendents have visited the Cavern daily, and have exercised the same care as heretofore in accurately recording the results from day to day.

The interest felt in the exploration by the inhabitants and visitors of Torquay has suffered no abatement; and the Superintendents have had the pleasure of conducting a large number of persons through the Cavern, including the Rev. Dr. Callaway, Bishop of Kaffraria, Rev. T. Bullivan, Rev. C. Chapman, Rev. S. C. Davis, Rev. W. W. Follett, Rev. W. M. Kingsmill, Rev. W. H.

Self, Rev. T. R. R. Stebbing, Rev. G. C. Swayne, Rev. Mr. Valpy, Rev. H. L. Williams, Rev. R. R. Wolfe, General Cotton, Col. Bushe, Lieut.-Col. J. G. R. Forlong (British India), Capt. Baudry (Bombay), Capt. J. C. Boyce, Capt. F. Miles, Dr. Ayerst, Dr. H. P. Blackmore, Dr. H. Evens, Dr. Hounsell, Dr. A. Parr, Dr. Topham, Dr. J. S. Burdon Sanderson, Dr. Wilks, and Messrs. C. A. Adamson, T. Aggs, G. Baudry (Bombay), W. Blackmore, W. H. Bridges, J. Duntze Carew, J. M. Curzon, M. Davidson, E. C. Dunn (Melbourne, Victoria), T. M. Eccles, A. B. Emmons (U. S. America), A. E. Fletcher, D. Hanbury, C. W. Hodson, E. D. Mashiter Hooper, T. Hunton, P. Q. Karkeek, E. Keep (Melbourne, Victoria), C. Lister, R. Lowndes, H. T. Mackenzie, J. I. Mackenzie, G. Meurling, F. A. Paley, T. M. Patterson, F. Rayner, G. F. Remfry, J. Hassard Short, J. Barclay Thompson, W. Vicary, T. Viccars, T. Warner, J. F. Webb, and H. Wyndham.

During a meeting at Torquay of the South-western Branch of the British Medical Association, the Cavern was visited by a large party of the members, attended by the Superintendents, including Dr. Aldridge, Dr. Baker, Dr. S. Budd, Dr. Dalby, Dr. Ellery, Dr. Finch, Dr. Harris, Dr. Henderson, Dr. Hudson, Dr. L. Shapter, Dr. W. R. Woodman, and Messrs. L. Armstrong, W. Brown, A. J. Cumming, J. Doidge, S. A. Gill, T. Harper, J. D. Harris, J. Kempthorne, W. C. Hunt, R. Kerswill, J. Lawton, H. E. Norris, T. E. Owen, C. Parsons, C. Pridham, G. T. Rolston, C. H. Roper, W. K. Spragge, A. J. Wallis, and J. Woodman.

The Cavern was also visited, under the guidance of the Superintendents, by Messrs. W. E. Blatch, A. B. Hill, A. D. Hill, W. R. Hughes, and J. Morley, members of the Birmingham Natural-History and Microscopical Society, during a scientific visit of that body to South Devon.

Besides the foregoing, a large number of visitors have been conducted by the Guide to the Cavern, appointed by the proprietor, Sir L. Palk, Bart., but who is placed under the directions of the Superintendents of the Exploration. In such cases the visitors are taken through those parts of the Cavern which have been explored, but not into the branches which have not been examined, or where the work is still in progress.

During May 1874 an arrangement was made with the Superintendents by Professor Alfred Newton, F.R.S., of Magdalen College, Cambridge, for Mr. H. H. Slater, one of the Naturalists to the Rodriguez Transit Expedition, to spend some time in the cavern studying the mode of exploration followed there, it being not improbable that he might have to explore some very interesting caves which exist in the island, and where, instead of intelligent men, he would probably have only half savages to dig for him. Mr. Slater reached Torquay on June 1st, when every thing was done to facilitate his purpose, and he spent some days watching the men at work.

Live rats continue to present themselves in the Cavern from time to time, and sometimes prove to be very troublesome. On Tuesday, October 7, 1873, one, which had been seen by the workmen, carried off six candles in the course of the afternoon, having detached them from a nail at a spot believed to have been inaccessible even to rats, and which had been used for the purpose during a period of three years without any previous loss. Gins were at once set for the marauder, and he was captured on the following Friday. On the 29th of the same month, another, between the hours of nine and one, ate through the basket in which one of the workmen had placed his dinner of bread and meat, and carried off every thing but the bread, the whole of which was left. A large number have been captured during the last twelve months.

It may not be out of place to remark that during the summer months

bees have frequently been seen and heard in the innermost branches of the Cavern, very far beyond any glimmering of daylight.

The Long Arcade.—It was stated in the Ninth Report (1873) that the "Long Arcade," after extending about 50 feet beyond the point reached by the excavators at the end of August 1873, terminated in a large chamber termed by Mr. MacEnery the "Cave of Inscriptions," and sometimes the "Cul-de-sac." On carefully perusing Mr. MacEnery's "Cavern researches," however, it was found that he regarded a large mass of Stalagmite on which are numerous inscriptions, and which it is proposed to call "The Inscribed Boss of Stalagmite," as being in the Cave of Inscriptions, and not, as the Superintendents considered, in the Long Arcade. In other words, he held that the line of junction of the two branches was on the north-east of the Inscribed Boss, whilst they drew it some distance on the south-west. To prevent ambiguity, it has been decided to adopt Mr. MacEnery's boundary and to regard the Long Arcade as extending from the south-west corner of the Sloping Chamber to, but not beyond, the Inscribed Boss. Thus defined, it stretches for about 225 feet in a tolerably straight line towards the south-south-west, varies in height from about 10 to 20 feet (the measurements being taken from the bottom of the excavations made by the Committee), and from 5 to nearly 20 feet in width.

Besides being the only passage to the Cave of Inscriptions, which may be regarded as its expanded prolongation, it throws off three branches on the left or eastern side and one on the right. Of the former, the first, or most northerly, is the "Charcoal Cave" described in the Eighth Report*, the second is known as "Underhay's Gallery," and the third, a few feet further south, consists of two successive and considerable chambers, termed "The Labyrinth" and "The Bear's Den." The branch on the other, or right, side, which it is proposed to name "Clinnick's Gallery," is at the inner extremity of the Arcade.

So far as this branch of the Cavern is concerned, Mr. MacEnery's researches entirely ceased about 12 feet before reaching the end of the Arcade, and throughout the remaining area the "Granular Stalagmite" (that which covers the "Cave-earth") was everywhere continuous, and varied from 12 to 30 inches in thickness. Its surface was occupied with large natural "Basins," some of them 12 inches deep, such as have been described in previous Reports†. Whilst the excavation was in progress several points of interest connected with the Basins were noted:—

1st. The Stalagmite forming their walls was harder and tougher than that surrounding them, whilst that composing their bottoms was comparatively soft and friable.

2nd. Their walls were traceable through the entire thickness of the Stalagmitic Floor; in other words, during the entire deposition of the Floor, Basins had existed in it, the bottom rising with the walls but at a slower rate.

3rd. The water which filled them in rainy seasons passed down through the bottom in 3 or 4 hours at most.

4th. Immediately beneath most of the Basins there was an almost continuous interspace of about half an inch vertically between the bottom of the Stalagmite and the top of the Cave-earth, caused, no doubt, by the finer particles of the deposit being carried by the percolating water through interstices to a lower level.

* Report Brit. Assoc. 1872, pp. 38-44.

† Ibid. 1872, p. 45, and 1873, p. 201.

It happened that the exploration of that part of the Arcade in which the Basins were thus numerous was carried on during a very wet season, when the water passing through the Stalagmitic Floor, as just mentioned, caused two or three slips in the Cave-earth and the "Breccia." The largest of these fell during the night of January 8th–9th, and in the fallen matter a tooth of Bear, a vertebra, fragments of bone, and a well-rolled flint nodule were found. It is, of course, impossible to say whether this nodule belonged to the era of the Cave-earth or that of the more ancient Breccia. This is to be regretted, as it is the only specimen of the kind which up to this time the Cavern has yielded.

The "Crystalline Stalagmite" (that which lies between the Cave-earth above and the Breccia below, when all these occur in the same vertical section) was also occasionally met with *in situ*, and always beneath the granular or less ancient variety. In some instances there was a space between them filled with the true Cave-earth with its characteristic bones and coprolites, whilst in others the two Stalagmites were in immediate contact. Where the older variety did not exist the Cave-earth lay at once on the Breccia.

The only noteworthy objects found in the Granular Stalagmite were a tooth of Bear, fragments of bone, one considerable "find" of coprolites, and charred wood on two occasions. The following is the complete list of objects of interest found in the Granular Stalagmite throughout the entire length of the Long Arcade from 1871–2 to February 23rd, 1874, when its exploration closed:—2 teeth of Hyæna, 1 of Bear, 1 of Deer, a large vertebra, fragments of bone on several occasions, several specimens of charred wood, a flint tool or "core" (No. 5990), and a piece of black flint.

Since the period at which the Ninth Report closed the undisturbed Cave-earth in the Long Arcade has yielded a considerable number of bones and fragments of bone and 63 teeth (30 of Hyæna, 24 of Bear, 4 of Horse, 3 of Mammoth, and 2 of Fox).

The total number of Teeth found by the Committee in undisturbed Cave-earth in the Arcade from first to last was about 340, which may be distributed as shown in the following Table:—

TABLE I.—Showing how many per cent. of the total number of Teeth found by the Committee in undisturbed Cave-earth throughout the Long Arcade belonged to the different kinds of Mammals.

Hyæna	41·5 per cent.	Deer	2 per cent.
Horse	21 ,,	Mammoth	2 ,,
Bear	14·5 ,,	Megaceros	1 ,,
Rhinoceros	9 ,,	Dog?	1 ,,
Fox	4·5 ,,	Lion	1 ,,
Pig	2·5 ,,	Machairodus	1 tooth only.

It is perhaps worthy of remark that in the Long Arcade, as elsewhere so far as the exploration has extended, wherever Cave-earth presented itself there also were remains of the Hyæna found, and in greater numbers than those of any other kind of mammal. Nor were his teeth and bones the only indications of his presence in the Arcade; for, to say nothing of the fact that some of the remains found with his were gnawed, nearly 40 "finds" of his coprolites were met with. They sometimes, though rarely, consisted of a solitary ball, whilst at others upwards of 20 were lying together and not unfrequently cemented into considerable lumps. Occasionally the amount of

matter of this kind found in a single day was sufficient to fill a very large basket.

The following specimens of flint and chert, found in the Long Arcade since the end of August 1873, belong to the Cave-earth era:—

No. 6304 is merely a flint chip so angular as to render it improbable that since its dislodgment from the nodule it has been in any way exposed to the action of flowing water. It was found in the first foot-level, with 2 teeth of Bear, bone chips (one of them being burnt), and 11 balls of coprolite, on December 13, 1873.

No. 6324, found December 30th, 1873, in the second foot-level, beneath the Floor of Granular Stalagmite from 2 to 2·5 feet thick, is a very symmetrical tongue-shaped tool, fashioned with much labour out of a chert nodule, and is worked to an edge all round the perimeter except at the butt-end, where portions of the original surface remain on both faces. It is 3·8 inches long, 2·3 inches in greatest breadth, 1·5 inch in greatest thickness, and convex on both faces, from each of which several flakes have been struck. Its era cannot be determined with perfect accuracy, since it occurred at or near the junction of the Cave-earth and the Breccia, where, unfortunately, they were not separated by Stalagmite. The fact that it was fashioned out of a nodule and not out of a flake, suggests that it belonged to the Breccia; and this finds some support from its occurrence in the second foot-level, for though the Cave-earth occasionally attained this depth in the inner part of the Arcade, it did so but rarely. On the other hand, its symmetrical outline and comparatively high finish are equally suggestive of the Cave-earth or less ancient period.

The presence of man in the Cave-earth of the Arcade was also indicated by several bones having the appearance of the action of fire. Specimens of this kind were met with on six different occasions.

Without including those found in the materials dislodged by their predecessors, the Committee have met with a total of 27 implements of flint and chert in Cave-earth which they found intact in the Long Arcade.

From the end of August 1873 to the end of July 1874 a considerable number of bones and 149 teeth of Bear, but no known remnant or indication of any other kind of animal, were found in the Breccia in the Arcade, making a total of about 200 teeth of this genus met with in this oldest deposit of the Cavern deposits, so far as is known at present, in the branch of the Cavern now under notice. Though several good specimens were obtained, none of them require special remark or description.

The same deposit yielded 10 tools, flakes, and chips of flint and chert during the year just closed.

No. 6186 is a chert pebble, displaying some chipping, but not sufficient to convert it into a useful tool. It was found in the third foot-level, without any other object of interest, September 2, 1873.

No. 6192 is a rude flake of flint, retaining a portion of the original surface of the nodule, and distinctly showing the "bulb of percussion." It was found alone, in the fourth or lowest foot-level, September 10, 1873.

No. 6201, a chert pebble, which has undergone some chipping and probably subsequent rolling, was found by itself in the second foot-level, September 18, 1873.

No. 6204 is simply a chip which has the appearance of having been artificially struck off a flint nodule, the original surface of which it retains on one face. It was found, with a few fragments of bone, in the third foot-level, September 23, 1873.

No. 6291, a piece of coarse chert, having the form of a horseshoe-shaped scraper, is about 2·1 inches long and broad, and ·7 inch in greatest thickness. The hinder end is sharply truncated, and the "bulb of percussion" is well developed near it on the inner face, but everywhere else its margin is a thin edge. It was found alone, in the fourth foot-level, November 29, 1873.

No. 6292, found on the same day and in the same "parallel" and "level" as No. 6291, but about 3 yards on the left of it, is a portion of a white flint, probably a "core" from which flakes had been struck. It retains a part of the original surface of the nodule. No other object was found near it.

No. 6299 is a rude flake of chert having little or nothing about it suggestive of an artificial origin. It has undergone the metamorphosis so frequently observed in Cave flints, by which it has acquired a granular chalky texture and has lost a part of its weight. It was found without any other object, in the third foot-level, December 8, 1873.

No. 6358, a coarse chert tool, which has also been metamorphosed, is of a very irregular nondescript form, and remains partially surrounded with Breccia. It was met with in the second foot-level, February 3, 1874, and was unfortunately broken by the workmen, but has been repaired.

No. 6364, a rather rude flake of coarse chert which has been rolled since it was struck off, retains much of the original surface of the nodule, and, though perhaps not intentionally fashioned as a tool, may have been utilized. It was found, with a tooth of Bear, bones and fragments of bone, in the third foot-level, February 14, 1874.

No. 6367, an angular chip of flint, was found, with 2 teeth of Bear and fragments of bone, in the fourth foot-level, February 23, 1874.

The entire number of noteworthy specimens of flint and chert (most of which, at least, have been made and used by man) which the Committee have found in the Breccia in the Long Arcade amounts to 27.

The materials which Mr. MacEnery had dug up and cast aside in that part of the Arcade explored during the period over which the present Report extends were found on examination to contain 13 teeth of Hyæna, 9 of Bear, 8 of Horse, 2 of Deer, 1 of Ox, several bones, numerous lumps of coprolite, and 1 flint flake (No. 6328). The specimens thus overlooked or neglected by the earlier explorers, which have been recovered by the Committee in the Long Arcade from first to last, are 63 teeth of Hyæna, 15 of Horse, 9 of Bear, 7 of Rhinoceros, 4 of Deer, 3 of Ox, 1 of Elephant, 1 of Fox, numerous portions of bones and of antlers, a large quantity of fæcal matter, and 9 tools and flakes of flint and chert.

Underhay's Gallery.—At about 185 feet from the entrance of the Long Arcade in the Sloping Chamber there is in the left or eastern wall, as already stated, a small lateral branch, to which the Superintendents have given the name of "Underhay's Gallery," after the late Mr. John Underhay, who for some years was Sir L. Palk's guide to the Cavern. Before the Committee commenced its exploration its mouth was almost closed with the large masses of limestone mentioned in the Ninth Report as lying in wild confusion beyond "The Bridge"*. Notwithstanding this, Mr. Underhay and his son forced a passage into the Gallery several years ago, even though after passing the entrance they must have found the Granular Stalagmitic Floor within a foot of the roof in certain places. They contrived, moreover, to bring back several small bones, which proved to be phalanges of human feet, which they had found *on* and *in* the Floor.

* Report Brit. Assoc. 1873, p. 199.

The Gallery extends about 20 feet in a south-easterly direction, varies from 2·5 to 7 feet in width, and, when measured from the bottom of the excavation made by the Committee, from 7·5 feet at the entrance to less than 6 feet in height within. The roof and walls have the appearance of an old watercourse, and are worn smooth, with but little of that fretted character so prevalent in some other branches of the Cavern. Near the mouth there are four circular holes in the right wall, about 6 inches in diameter, which look like the mouths of "flues," but are found to extend not more than a foot into the rock and to run into one another. A Floor of the Granular Stalagmite, never exceeding 10 inches in thickness, extended from the mouth to 16 feet within it, where it "thinned out." Beneath it there were, in certain places, chiefly adjacent to the left wall, remnants of the Crystalline Stalagmite *in situ*; but the greater part of this older Floor had, as in many other parts of the Cavern, been broken up by some natural agency.

With rare exceptions, a thin layer of Cave-earth lay at once on the Breccia without any Stalagmite between them. In the Breccia itself, however, there were numerous fragments or blocks of Stalagmite which cannot but be regarded as remnants of a Floor still older than the Crystalline Stalagmite found on the Breccia. Similar indications of this Floor, of what may be called the third order of antiquity, have frequently been met with elsewhere in the Cavern, and mentioned in previous Reports*. The Breccia was extremely hard, and had to be split out with wedges to the depth of 2 feet. This, added to the contracted dimensions of the Gallery, rendered the work probably the most severe that has been experienced in the Cavern from the commencement.

Though the human bones found by Mr. Underhay *on* and *in* the Granular Stalagmite, as already mentioned, did not appear, from their aspect or specific gravity, to be of an antiquity equal to that of the Cave-hyæna and his contemporaries, the Superintendents, in the hope of finding some further traces of the skeleton, very carefully watched the progress of the work; and on reaching Mr. Underhay's very limited diggings, they met with a series of bones also *on* and *in* the Stalagmite, some of which were certainly human, whilst others were as clearly infra-human. The whole were at once forwarded to Mr. George Busk, F.R.S. &c., a member of the Committee, who has been so good as to forward the following report on them. They were all numbered $\frac{1}{6261}$, $\frac{2}{6261}$, &c., $\frac{1}{6285}$, $\frac{1}{6289}$, $\frac{2}{6289}$, &c., and so on.

Mr. Busk's Report.

"I. *Human.*

No.
6261. 1. Lower end of left humerus.
6285. 1. Right astragalus (small size).
4. Fragment of rib.
5. Do. do.
6. Second phalanx of fourth finger.
7. Fragment of proximal epiphysis of humerus.
8. Fragment of eleventh or twelfth rib.
9. Fragment of cervical vertebra.
10. Fragment of rib?
11. Navicular bone.

* See Report Brit. Assoc. 1868, p. 57.

No.
6285. 12. A trapezium.
13. Fragment of rib.
14. Fragment of cervical vertebra.
15. Fragment of rib.
17. Second phalanx of fourth toe.
18. Do. do. do.
6289. 1. Fragment of rib.
2. Right patella.
3. Right first metatarsal.
4. Right ectocuneiforme.
6. Fragment of cervical vertebra.
7. Fragment of lumbar (first) vertebra.
8. Fragment of axis vertebra.
9. Fragment of cervical vertebra.
10. Do. do. do.
13. Second phalanx of little finger.
14. Fragment of rib.
15. Fragment of cervical vertebra.

"II. *Not Human.*

No.
6285. 2. Gnawed fragment of small cannon-bone of Sheep or Goat.
3. Fragment of shaft or humerus of very young Sheep or Goat.
6. Ungual phalanx of very small Sheep (not Goat nor Roebuck).
6289. 5. Ectocuneiforme of very large Deer.
11. Fragment of tooth of ?
12. A tooth ?
6261. 1*a*. Fragment of skull of ?

"With respect to the human remains, they appear to be those of an adult individual of small size and delicate make, probably therefore, at that period, a female; but it is impossible to speak positively as to this. I should imagine them not necessarily of any very remote antiquity.

"The Sheep must have been of the smallest Welsh type.

"There are two or three specimens of a much more ancient type. One of these ($\frac{5}{6289}$) is the ectocuneiforme of a Deer as large, I imagine, as the Wapiti Deer. Another is the fragment of a large tooth ($\frac{11}{6289}$), it may be of Bear or Hyæna; and the third ($\frac{12}{6289}$) is a single-fanged tooth of singular form, which may by remote possibility be a premolar of a large Bear. These specimens are in a widely different mineral condition from that of the human and ovine remains.

(Signed) "GEORGE BUSK."

"32 Harley Street, January 3, 1874."

When the very contracted character of this Gallery, prior to its excavation by the Committee, is borne in mind, it is difficult to understand how the remains were introduced. There were neither potsherds, nor charcoal, nor, in short, any thing suggesting that the bones were the remnants of a body disposed of by cremation, such as were met with in the Charcoal Cave *; nor were there any marks of teeth on the bones such as might have been expected had they been taken thither by a carnivorous animal, or the relics of

* See Report Brit. Assoc. 1872, pp. 38–41.

a skeleton buried or secreted there, of which all other portions had been carried off by some carnivore.

The commingling of a few specimens of a more ancient type with the comparatively recent human and ovine remains was no doubt produced by Mr. Underhay's diggings at the spot.

Besides the foregoing specimens no object of interest was found in connexion with the Granular Stalagmite.

The Cave-earth in Underhay's Gallery yielded 2 balls of coprolite, numerous bones, and 94 teeth; of which 61 were those of Hyæna, 22 of Horse, 4 of Rhinoceros, 4 of Fox, 1 of Bear, 1 of Lion, and 1 probably of Wolf.

The following specimens of flint and chert were also met with in the Cave-earth:—

No. 6234, a mere angular chip of drab-coloured flint, was found, with 1 tooth of Hyæna and one of Rhinoceros, in the first foot-level, October 14, 1873.

Nos. $\frac{1}{6269}$, $\frac{2}{6269}$, and $\frac{3}{6269}$ are three small fragments of flint (two of them angular and the third subangular), having no appearance of having been artificially formed, and were found, with 7 teeth of Hyæna and 1 of Fox, part of a jaw of Fox, part of a skull, and a gnawed bone, in the first foot-level, November 10, 1873.

No. 6289 is a small bit of flint, found, with 15 teeth of Hyæna, 7 of Horse, 1 of Bear, and a few bones, lying *on* the Cave-earth in the innermost part of the Gallery, beyond the point at which the Granular Stalagmite had thinned out.

The Breccia in Underhay's Gallery produced several bones, 115 teeth of Bear, and the following specimens of flint and chert:—

No. 6220, an irregular flint chip, which has been somewhat rolled, was found, with three teeth of Bear and fragments of bone, in the second foot-level, October 30, 1873.

No. $\frac{1}{6221}$ is apparently a flint "core," which retains a portion of the original surface of the nodule, and was found, with three teeth of Bear, also on October 30, 1873, and one foot below No. 6220.

No. $\frac{2}{6221}$ is a rolled flake of chert found with No. $\frac{1}{6221}$.

No. 6279 is a flake of chert still imbedded in the Breccia, and was found, with bone fragments, in the second foot-level, November 17, 1873.

No. 6281 is a small flake of chert, found, with three fragments of teeth of Bear and pieces of bone, in the fourth foot-level, November 18, 1873.

The Breccia in this Gallery also yielded a piece of iron-ore and a small piece of umber.

The Inscribed Boss of Stalagmite.—Though inscriptions exist in various parts of the Cavern, the huge mass of Stalagmite, standing at the point where the Long Arcade, the Cave of Inscriptions, and Clinnick's Gallery meet, is, with the exception perhaps of the "Crypt of Dates"*, more thickly scored with names, initials, and dates than any other equal area within the Cavern. Indeed it seems to have been the spot where visitors usually left their names. Those alone who were sufficiently adventurous and expert to get beyond the "Lake" could leave a proof of the fact in the Crypt. The Boss, which may be described as a frustum of an oblique cone, measures 43 feet in basal circumference and 14 feet along the slant side, which, forming an angle of 70° with the horizon, gives a vertical height of fully 13 feet. The cubic contents are probably not less than 630 cubic feet of Stalagmite. Its

* See Report Brit. Assoc. 1869, pp. 194–196.

base consists of the Older or Crystalline Stalagmite, and the upper portion (without any intervening Cave-earth) of the Granular variety, which not only surmounted and completely encased the former, but, by flowing in vast sheets, formed the thick Granular Floor spreading far and without a break in every direction.

The inscriptions occupy its outer or most accessible semi-surface, where in certain places they form quite a network. Letters of all sizes, from some fully three inches in height to others as small as ordinary writing, cross each other and add to the difficulty of decipherment. Some of them were cut with great care and finish, and must have occupied a large amount of time, whilst others were but hasty scratches.

It seems to have been somewhat fashionable to surround the inscriptions with rectangular parallelograms, varying from 6·5 to 3·75 inches in length by 5·5 to 3·5 in breadth. In, at least, one or two cases the cutting of the parallelogram preceded that of the inscription, as the latter extends beyond the space intended. Not unfrequently several names occur together, whether within a parallelogram or not, and in each such case the entire work seems to have been performed by the same hand. The following, which are the most legible, may suffice as examples:—

*1. PETER LEMAIRE
RICH: COLBY OF
LONDON. 1615.

2. THOMAS TRENHELE
1617.

3. IANE
PRIDE
ÆLIXI
1626 †

4. 16 [??] ‡
ÆMBROSE LANE
MILDRED
TORKINTON

5. JOHN TAYLOR
1700

6. VIZARD
1809

7. R. H. THOMAS
LONDON
1811

8. RICHARD
LANE. FEB.

9. M. CHAMPERNOWNE
GILBART
STAPLYN §

10. DELVC

11. W. P. WILLIS

12. N. I. FURSE

13. W. WISH

14. I. WISH

15. R. LEAR

16. R. CRAMPTON

17. JOB. F. LIEVR

* The numerals prefixed to the inscriptions form no part of the original. Mr. MacEnery, who copied some of these inscriptions, appears to have made a few mistakes. Thus, in No. 1, instead of "Lemaire" he copied "Lemaine," and instead of "Colby," "Calley;" and in No. 4, instead of "Torkinton," "Torkington." (See Trans. Devon Assoc. vol. iii. p. 275, 1869.)

† The first three lines of No. 3 are within a parallelogram, 4·75 in. × 3·25 in., having the date, which seems clearly to belong to it, immediately below. It does not seem easy to attach a meaning to the third line.

‡ The two last figures of the date in the upper line of No. 4, represented above by two notes of interrogation within brackets, are illegible.

§ The characters employed in No. 9 are very peculiar, and are the same for the three names, which are close together, and clearly were inscribed at the same time.

Of the foregoing names, No. 10 may perhaps be that of Mr. J. A. DELUC, F.R.S. &c. He visited Torquay in October 1805, but, as the following passage in his 'Geological Travels' shows, does not appear to have entered the Cavern at that time. Speaking of the "*lime-stone strata*," between Babbicombe and Tor Bays, he says, "There is, as I was told, a succession of caverns within this mass, resembling those of the *Mendip hills*, which I shall hereafter describe: the Caverns here have the name of *Kent's Cave*"*. This appears to be the only mention he makes of the Cavern. The inscription is in comparatively small capitals, which, though no great pains appear to have been bestowed on them, are very distinct, and stand immediately above the parallelogram containing the inscription No. 1.

The name of Champernowne (No. 9) is that of a well-known Devonshire family, now represented by A. Champernowne, Esq., F.G.S., of Dartington House, near Totnes, the seat of his ancestors for many generations. It is worthy of remark, perhaps, that the mother of Sir Humphrey Gilbert, born near Torquay, the half-brother of Sir Walter Raleigh, was a Champernowne. In the inscription, however, the name is Gilbart, not Gilbert. Whether "Staplyn," also in No. 9, is the name of a person or of a place, there seems to be no mode of determining; but it may be observed that "Staple" is the name of a hamlet in the parish of Dartington.

Some of the names inscribed on the boss are no doubt those of persons of the immediate neighbourhood. "W. Wish" (No. 13) was the name of one of the principal builders at Torquay when Mr. MacEnery's Cavern researches were in progress, and he had a nephew named "James Wish" (No. 14). The name of "Lear" (No. 15) is very prevalent in the adjoining parish of St. Mary Church.

It must be unnecessary to add that every care has been taken to preserve this Boss with its inscriptions uninjured.

The Cave of Inscriptions.—Though the principal entrance to Clinnick's Gallery is between the Inscribed Boss of Stalagmite and the right wall of the Long Arcade, a second, but smaller one, opens out of the Cave of Inscriptions immediately beyond the Boss; in fact the original entrance was partially filled, and thus converted into two, by the Boss. As the smaller of the two entrances was the more convenient for excavating the Gallery, it was decided to complete the exploration of the Cave of Inscriptions so far as to render this entrance available, that is up to 16 feet from its commencement. Mr. MacEnery had not broken ground in any part of this area, and the Granular Stalagmitic Floor was everywhere intact and continuous from the slopes of the Inscribed Boss. The Crystalline Stalagmitic Floor lay beneath it, and, as already stated, formed the base of the Boss without any intermediate deposit; but towards the left or remote wall of the Cavern there was a space between them filled with a wedge-like layer of Cave-earth. Not unfrequently, however, the lower or older Stalagmite had been broken. In some instances the severed portions were not dislodged, whilst in others considerable masses had been removed by some natural agency, and were not always traceable.

In this commencement of the Cave of Inscriptions the Cave-earth yielded 20 teeth, of which 11 were those of Bear, 5 of Elephant, 3 of Hyæna, and 1 of Horse. There were also several bones, of which 6 had been burnt and a few gnawed; and a considerable quantity of coprolitic matter was met with in 14 distinct "finds."

* 'Geological Travels,' by J. A. De Luc, F.R.S., vol. ii. 1814, p. 300.

The following specimens of flint and chert were also found in the Cave-earth in this branch of the Cavern:—

No. 6378 is a mottled, grey, angular flake of chert, 2·3 inches long, 1·5 inch broad, ·3 inch thick, very concave on the inner face, and has had several flakes struck off the outer face. There is little or no evidence of its having been used, and it was found, with two specimens of plates of Elephant molars, 2 teeth of Bear, gnawed bones, 1 burnt bone, and 5 lumps of coprolite, in the first foot-level, March 6, 1874.

No. 6382, a small grey flint flake or chip, with the "bulb of percussion" strongly marked, was found in the first foot-level beneath a cake of stalagmite 12 inches thick, with 3 teeth of Bear and 11 balls of coprolite, March 11, 1874.

No. 6384 is a rudely lanceolate flake of grey flint, 2·2 inches long, ·9 inch in greatest breadth, ·3 inch in greatest thickness, slightly concave on the inner face, reduced to an edge along both lateral margins, having two ridges extending its entire length on the outer face, and has been but little, if at all, used. It was found, with 4 teeth of Bear, fragments of bone, and a coprolite, in the first foot-level, March 13, 1874.

No. 6390 is a small flint flake, 1·4 inch long, ·8 inch in greatest breadth, ·3 inch in greatest thickness, slightly concave in both directions on the inner face, strongly carinated on the other, sharply truncated at each end, reduced to an edge on the lateral margins, one of which is broken or jagged, of a light drab colour on the surface and to some depth below it, but retaining the original almost black colour at the centre. It was found in the first foot-level beneath 10 inches of stalagmite, with 1 tooth of Bear, 2 fragments of burnt bone, and 4 lumps of coprolite, March 24, 1874.

No. 6399 is a nearly white flint of fine texture, 2·9 inches long, varying from ·7 to ·9 inch broad, ·5 inch in greatest thickness, sharply truncated at the butt-end, round-pointed and blunt at the other, sharp and unworn at the lateral margins, longitudinally concave on the inner face, and having a strong central ridge on the other extending from the butt-end nearly two thirds of its length, where it bifurcates in consequence of the dislodgment of a small flake, which has left an uneven surface. At the butt-end there is on one of the slopes a portion of the original surface of the nodule about an inch long, and the "bulb of percussion" is well developed near the point. It was found, with 2 fragments of bone and 2 lumps of coprolite, in the first foot-level beneath a layer of Granular Stalagmite 24 inches thick, on April 1, 1874.

No. 6435 is a grey flint flake, 1·5 inch long, ·7 inch broad, ·35 inch in greatest thickness, which it attains along one of its lateral margins, sharply truncated at one end, round-pointed and blunt at the other, where, on the inner face, the "bulb of percussion" presents itself, reduced to a thin edge along one of its lateral margins, where there are indications of its having been used as a scraper. On its outer face it has, for a short distance near the middle of its length, a central ridge which bifurcates towards each end. It was found in the first foot-level on May 28, 1874.

Nothing was met with in the Crystalline Stalagmite; but the Breccia beneath it yielded remains of Bear as usual, including numerous bones and fragments of bone and 91 teeth, but, so far as is known, no trace of any other animal.

The following specimens of flint and chert were also met with in this oldest of the Cavern deposits:—

No. 6375 is a large rude flake of a very rough flint nodule, which has undergone sufficient metamorphosis to produce a granular texture and render it capable of being scratched with a knife, but without any marked loss of weight. Its form is rudely quadrilateral with the angles rounded off. The inner face displays the "bulb of percussion" near the truncated butt-end, but elsewhere has a tendency to flatness. The outer face retains a large portion of the original surface of the nodule. It is 4·25 inches long, 3 inches broad, 1·5 inch in greatest thickness, and was found in the fourth or lowest foot-level, with 2 teeth of Bear and a small flint pebble, March 3, 1874.

No. 6388 is a bluish-grey flint of somewhat coarse texture, 2 inches long, ·7 inch broad at the truncated butt-end, whence it tapers to a point at the other, ·4 inch in greatest thickness, slightly concave on one face and very strongly ridged on the other. It was found, with 2 teeth of Bear and fragments of bone, in the second foot-level, March 17, 1874.

No. 6392, an irregularly shaped flake or chip of pinkish drab chert, 2·2 inches long, 1·8 inch broad, and ·3 inch in greatest thickness, was found, without any other object of interest, in the third foot-level, March 25, 1874.

No. 6396 is a subtriangular flake of coarse chert, 1·8 inch long, 1·1 inch in greatest breadth, ·4 inch in greatest thickness, nearly flat on one face and has a strong curvilineal ridge on the other. It was found, with fragments of bone, in the first foot-level, March 31, 1874.

No. 6455 is a small specimen, or rather a portion of one, it having been broken in extracting it from the matrix. It is ·9 inch long, scarcely ·5 inch broad, and ·2 inch in thickness, which it retains to each of its lateral margins. It was found, with fragments of bone, in the fourth foot-level, June 19, 1874.

Clinnick's Gallery.—As already stated, the Long Arcade throws off a lateral branch at its inner extremity, at its junction with the Cave of Inscriptions and in the right wall. Its principal entrance is about 225 feet from the mouth of the Arcade. It was left entirely untouched by Mr. MacEnery; but in 1846 the Torquay Natural-History Society appointed a Committee of three of its Members, including the two Superintendents of the present work, to make some very limited researches in the Cavern. That Committee broke ground in three different places, and found flint implements in each. One of the spots selected was the smaller or innermost of the two mouths of this Gallery, immediately behind the Inscribed Boss of Stalagmite. Mr. Vivian, speaking of the flint tool found there, says, "In the spot where the most highly finished specimen was found the passage was so low that it was extremely difficult, with quarrymen's tools and good workmen, to break through the crust; and the supposition that it had been previously disturbed is impossible"*. The specimens found during those researches are now in the Museum of the Torquay Natural-History Society.

The work on that occasion was performed as in all previous cases: the excavated materials were examined by candlelight as they were dug out, and then thrown on one side, but not taken out of the Cavern to be re-

* See Report Brit. Assoc. 1847, Proceedings of Sections, p. 73. Also Trans. Devon Assoc. vol. ii. p. 518 (1868).

examined by daylight. The excavation was about 7·5 feet long, 5 feet broad, and penetrated to a depth of not more than 2 feet below the bottom of the Granular Stalagmitic Floor. The materials then cast aside have been taken out of the Cavern by your Committee, and the following objects found in it:—7 teeth of Bear, 1 of Fox, and 13 lumps of coprolite. Before its removal, the surface of the mass was carefully examined to ascertain what thickness had been reached by the Stalagmite which, as the Superintendents well knew, had been accreting on it since its lodgment in the spot it had occupied for 28 years, beneath one of the overhanging walls of the Cavern: the result was a film of the thickness of writing-paper only, and limited to two examples of from 2 to 3 square inches each. When your Committee began the exploration of this Gallery, they supposed it likely to prove but a very small affair; but at the end of July 1874 three months' labour had been expended on it, and it is still unfinished. The Granular Stalagmitic Floor so very nearly reached the Roof as to lead to the conclusion that the entire Gallery was exposed to view; but as the work advanced the space between the Floor and Roof became steadily greater, until John Clinnick, the workman after whom the Gallery is named, was able to force himself through the low tunnel, and to enter a chamber which he speaks of as being large and beautifully hung with Stalactites.

This Gallery, up to the point at present explored, must have had a perfectly continuous floor of Granular Stalagmite before it was broken in 1846, as already stated. It varied from 14 to 30 inches in thickness; and at about 3 feet from the base of the Inscribed Boss there rose from the Floor another, in the form of a tolerably regular paraboloid, which, though dwarfed by its gigantic companion, would have arrested general attention elsewhere. It measured 10 feet in basal circumference, 3 feet in height, and had to be blasted in order to effect its removal, when it was found to be pure stalagmite throughout.

Up to 18 feet from the entrance of the Gallery a small quantity of Cave-earth uniformly presented itself, beneath which lay the Breccia occasionally separated from it by remnants of the Crystalline Stalagmite *in situ*; but at the point just mentioned the upper Stalagmite rested immediately on the lower, and that on the Breccia; and this condition has been retained up to the present time, that is through an area 16 feet long. The Committee, however, are not unprepared to find Cave-earth, at least in the form of "pockets," between the two Floors, with its characteristic remains, as the work progresses, as was the case in the "South-west Chamber"*.

The Cave-earth in Clinnick's Gallery yielded 8 teeth of Hyæna, 2 of Fox, a tolerable number of bones, 13 "finds" of coprolite, and the following specimens of flint and chert:—

No. 6401 was a rather large chert implement broken into several pieces by a blow of the workman's tool. It was found, with a tooth of Hyæna, in the first foot-level, on which the Granular Stalagmite was 24 inches thick, on April 7, 1874.

No. 6426 is a small white flint flake, 1·3 inch long, 1 inch broad, ·3 inch in greatest thickness, nearly flat on one face, strongly ridged rather near the margin on the other, blunt at the ends, but reduced to a thin edge everywhere else; one margin is nearly straight, whilst the other is an almost circular arc, giving the specimen a semicircular form. It has undergone

* See Report Brit. Assoc. 1869, p. 193.

the prevalent metamorphosis, and was found in the first foot-level, May 12, 1874.

The Breccia in this Gallery had produced, up to the end of July 1874, 86 teeth of Bear, numerous bones, including a large portion of a skull (No. 6458), and the following specimens of flint and chert:—

No. 6403 is a pinkish drab flake of chert, somewhat pentagonal in form, about 2·1 inches long, 1·5 inch broad at what may be regarded as its front edge, ·45 inch in greatest thickness, and probably an efficient "scraper." It was found alone in the fourth foot-level, April 15, 1874.

No. 6415, a pinkish drab flake of chert, 2·2 inches long, 1 inch broad, ·35 inch in greatest thickness, with the "bulb of percussion" on the inner face, which is concave in both directions, whilst the outer face is convex and retains the original surface of the nodule on about one third of its length. It does not appear to have been used, but a considerable part of its margins are concealed by portions of the Breccia. It was found, with 3 teeth of Bear, in the first foot-level, April 28, 1874.

No. 6427 is an irregular pentagon in form, 2·9 inches in length, 2·4 inches in greatest breadth, ·9 inch in greatest thickness, nearly flat on one face, which shows the "bulb of percussion," and convex on the other, whence several flakes have been dislodged leaving conchoidal facets. It was probably reduced to a thin edge along each of its sides except one; and it seems to have been pretty much used. It was found, with fragments of bone, in the fourth foot-level, May 14, 1874.

No. 6462 is a rough irregular flake, 2·4 inches in length, 1·2 inch in greatest breadth, and ·5 inch in greatest thickness. It was found, with a Bear's tooth and a few fragments of bone, in the first foot-level, July 13, 1874.

No. $\frac{1}{6411}$, the finest stone implement found in the Breccia since the Ninth Report was presented, has, on that account, been reserved for the last to be here described. It was found April 23, 1874, in the fourth or lowest foot-level, with 1 tooth of Bear, fragments of bone, and a small chert flake ($\frac{2}{6411}$) which had probably been rolled. It measures 4·5 inches in length, 3 inches in greatest breadth, 1·1 inch in greatest thickness, is very convex on one face, slightly so on the other, retains a portion of the original surface near the butt-end, and is rudely quadrilateral in form with the angles rounded off. Several flakes have been struck off each face; the edge to which it has been reduced along its entire margin, except at the butt-end, is by no means sharp; its surface is almost entirely covered with an almost black, probably manganesic, smut, whilst a slight chip near the pointed end shows it to consist of a very light-coloured granular chert. Several lines, betokening planes, probably, of structural weakness or perhaps of fracture, entirely surround it. If it has really been fractured, it must have occurred where the tool was found, and the parts have been naturally reunited without being faulted. Its character, as well as its position, shows that this fine implement belonged to the era of the Breccia.

This specimen is of considerable interest, both on account of the lines which cross its surface and of the position it occupied.

Amongst the flint implements found in Brixham Cavern, that known as No. 6–8 has attracted considerable attention, and has been described and figured by Mr. John Evans, F.R.S., P.G.S., a member of the Committee, both in his 'Ancient Stone Implements'* and in the "Report on the Explora-

* 'Ancient Stone Implements, &c. of Great Britain,' by John Evans, F.R.S., F.S.A., 1872, pp. 468–469, fig. 409.

tion of Brixham Cave"*. It was found in two pieces—the first on the 12th of August, 1858; the second, 40 feet from it, on the 9th of the following September; and it was not until some time after the latter date that the late Dr. Falconer discovered that the two fragments fitted each other, and, when reunited, formed a massive spear-shaped implement. The lines on the Kent's Cavern implement just described ($\frac{1}{6411}$) show that it had either been fractured where it was found, or, what seems more probable, that it is traversed by planes of structural weakness, such that a slight blow would break it into two or more pieces, which a stream of water would easily remove and probably separate, and thus produce a repetition of the Brixham case.

The Kent's Cavern tool was found in a small recess in the wall, just within the outer or wider entrance of Clinnick's Gallery, a very few feet from the Inscribed Boss of Stalagmite, and, as has been already stated, in the fourth foot-level of the Breccia—that is, at the greatest depth in the oldest of the Cavern deposits to which the present exploration has been carried; and is thus wonderfully calculated to take the mind step by step back into antiquity.

First, very near the spot occupied by the specimen there rises a vast cone of Stalagmite, which an inscription on its surface shows has undergone no appreciable augmentation of volume during the last two and a half centuries.

Second, prior to that was the period spent in rearing the greater portion of this cone, which measures upwards of 40 feet in basal girth, reaches a height of fully 13 feet, and contains more than 600 cubic feet of stalagmitic matter.

Third, still earlier was the era during which the Cave-earth was introduced, in a series of successive small instalments with protracted periods of intermittence, when the Cavern was alternately the home of man and of the Cave-hyæna, and the latter dragged thither piecemeal so many portions of extinct mammals as to convert the Cave into a crowded palæontological Museum.

Fourth, further back still was the period during which the base and nucleus of the cone or boss was laid down in the form of Crystalline Stalagmite.

Fifth, and earliest of all, was the time when materials, not derivable from the immediate district, were carried into the Cavern through openings now probably choked up, entirely unknown, and the direction in which they lie but roughly guessed at—when, apparently, the Cavern-haunting Hyæna had not yet arrived in Britain. At an early stage in this earliest era man occupied Devonshire; for prior to the introduction of the uppermost four feet of the Breccia one of his massive unpolished tools, rudely chipped out of a nodule of chert, found its way into a recess in the Cavern, and having a character such as to show that it must have lain undisturbed in the same spot until it was detected by a Committee of the British Association.

It may be of service before closing this Report to show, in a tabular form, the distribution of the different kinds of Mammals in the Cave-earth in various branches of the Cavern.

* Phil. Trans. vol. clxiii. part 2, pp. 550–551.

Table II.—Showing how many per cent. of the Teeth found in the Cave-earth, in different branches of the Cavern, belonged to the different kinds of Mammals.

	South Sally-port.	North Sally-port.	Smerdon's Passage.	Sloping Chamber.	Wolf's Cave.	Cave of Rodentia.	Charcoal Cave.	Long Arcade.	Underhay's Gallery.
Hyæna	27	31	43	39	44·5	44	29·5	41·5	65
Horse	29	31	27	28·5	25	28	33	21	23·5
Rhinoceros	11	16	15	14	15	9·5	10·5	9	4·25
Bear	8	1	2	2·5	3	3	3·5	14·5	*
Sheep †	7	·5	..	..	·5	·5	1	..	..
Badger	3	4	2·5	..	..	..	6	..	..
Fox	3	·5	1·5	..	*	*	12	4·5	4·25
Rabbit........	3	2	·1	..	·5	..	..	..	..
Elephant	2	2	·2	1·5	2·5	1	1	2	..
Deer ‡........	2	6	7	8·5	5·5	9·5	..	3	..
Lion	2	2	·5	1	1	..	..	1	*
Ox	1	·5	3	2	1	2	1	..	..
Wolf	·5	..	·5	1	1	*	2·5	..	*
Hare	·5	·5	..	..	..	..	..	..	..
Dog?	·5	..	·25	*	..	..	..	1	..
Pig	·5	·5	..	..	..	..	..	2·5	..
Beaver	..	·5	..	..	..	..	..	..	..
Bat	..	..	·15	..	..	..	..	..	..
Machairodus ..	..	..	..	..	..	..	..	*	..

No trace of *Machairodus* has been met with since the Eighth Report (1872) was presented.

Report of the Committee, consisting of Dr. Gladstone, Dr. C. R. A. Wright, *and* W. Chandler Roberts, *appointed for the purpose of investigating the Chemical Constitution and Optical Properties of Essential Oils. Drawn up by* Dr. Wright.

Since the last Meeting of the Association the following results have been obtained:—

I. Oil of Wormwood (*Artemisia Absinthium*, L.).—By fractional distillation, a sample of pure oil obtained from Dr. S. Piesse was split up into:—(1) A terpene boiling at about 150°, and constituting about 1 per cent. of the oil. (2) A smaller quantity of hydrocarbon, probably a terpene, boiling between 170° and 180°. (3) An oxidized product, the *absinthol* of Gladstone, indicated by the formula $C_{10}H_{16}O$, and hence isomeric with camphor, boiling at 200°–201° (corrected): this product was first obtained by Leblanc, and stated by him to boil at 204°; Gladstone found the boiling-point to be 217°; whilst

† There is reason to believe that the remains of Sheep found in the Cave-earth had been introduced in comparatively recent times by burrowing Carnivores.

‡ The "Irish Elk," Reindeer, Red Deer, &c. are all included under the general name "Deer." The asterisks in the Table denote that only 1 tooth was found.

in a paper published during the progress of these experiments Beilstein and Kupffer state that the substance boils at 195°. (4) Resinous substances not volatile at 350°. (5) "Blue oils" boiling at near 300° and upwards.

Absinthol differs from its isomeride myristicol (boiling at 212° to 218°, or about 15° higher) in that it is not appreciably polymerized by continued rectification; like this substance, however, it is dehydrated by hot zinc chloride forming cymene, thus,

$$C_{10}H_{16}O=H_2O+C_{10}H_{14};$$

the yield of cymene is, however, but small (20 to 25 per cent.), most being converted into a non-volatile resinous mass.

When treated with phosphorus pentasulphide absinthol loses the elements of water, cymene resulting; the yield of this hydrocarbon is not much greater than when zinc chloride is used: a portion of the absinthol also becomes converted into *cymyl-sulphhydrate*, $C_{10}H_{13}.SH$, apparently identical with that obtained from camphor by similar treatment; camphor and absinthol, therefore, are identical in so far as the action of pentasulphide of phosphorus is concerned. The production of cymene from absinthol in this way has also been observed by Beilstein and Kupffer, who, however, did not observe the simultaneous production of cymyl-sulphhydrate.

II. Oil of Citronella (*Andropogon Schœnanthus*).—A pure sample of this oil was found to consist mainly of an oxidized substance boiling at near 210°, but altered by continued heating, becoming somewhat resinized and partially losing the elements of water. This substance gave numbers on combustion agreeing with those calculated for the formula $C_{10}H_{18}O$; therefore it is isomeric, not with camphor, myristicol, and absinthol, but with *cajeputol* from oil of cajeput. (Gladstone found in a sample of citronella a body termed by him *citronellol*, boiling pretty constantly at 199°–205°, which gave numbers agreeing sharply with the formula $C_{10}H_{16}O$; essential oils not improbably differ in the character of their ingredients with the season, age of plant, &c.)

When two equivalents of bromine are cautiously added to this oxidized substance combination takes place, much heat being evolved; the resulting dibromide breaks up on heating into water, hydrobromic acid, and cymene, thus,

$$C_{10}H_{18}Br_2O=H_2O+2HBr+C_{10}H_{14},$$

a considerable amount of resinous by-products being also formed.

When treated with phosphorus pentasulphide, the first action is the removal of the elements of water, a terpene or a mixture of terpenes boiling between 160° and 180° being formed, thus,

$$C_{10}H_{18}O=H_2O+C_{10}H_{16};$$

polymerides of terpenes boiling at about 250° and upwards are also produced; by a further action the terpene becomes partially converted into cymene, sulphuretted hydrogen being evolved, thus,

$$C_{10}H_{16}+S=H_2S+C_{10}H_{14}.$$

When heated with zinc chloride the oxidized constituent of citronella-oil is decomposed, a mixture of hydrocarbon being apparently formed, amongst which a terpene boiling between 170° and 180° predominates; nine tenths of the substance are, however, converted into a resinous non-volatile mass.

Phosphorus pentachloride forms a chlorinated product which splits up on

heating, forming hydrochloric acid, a terpene boiling between 168° and 173° and polymerides of higher boiling-point, the reactions being

$$C_{10}H_{18}O+PCl_5=HCl+POCl_3+C_{10}H_{17}Cl$$

and

$$C_{10}H_{17}Cl=HCl+C_{10}H_{16}.$$

III. Oil of Cajeput.—The "cajeputene hydrate" of Schmidt (the "cajeputol" of Gladstone) was approximately isolated from resinous higher boiling substances simultaneously present in the oil by fractional distillation, and boiled between 176° and 179°, or more than 30° lower than the isomeric substance from citronella-oil; like its isomeride, it combined with two equivalents of bromine, evolving much heat, and forming a dibromide splitting up by heat into hydrobromic acid, water, and cymene, thus

$$C_{10}H_{18}Br_2O=2HBr+H_2O+C_{10}H_{14}.$$

The yield of cymene, however, was much greater with the cajeputol dibromide than with the citronella product, 100 parts of $C_{10}H_{18}O$ from cajeputol yielding about 67 parts of cymene, and 100 of that from citronella less than half as much.

With phosphorus pentasulphide cajeputol behaves just as its isomeride, forming first a terpene and then cymene, the elements of water being first abstracted, and then two equivalents of hydrogen removed.

IV. Action of Phosphorus Pentasulphide on Terpenes.—In order to prove that the cymene formed when pentasulphide of phosphorus acts on the products $C_{10}H_{18}O$ from citronella and cajeput oils is really produced from a terpene first generated, the action of phosphorus pentasulphide on other terpenes was examined, oil of turpentine (boiling at 159°) and hesperidene (boiling at 178°) being chosen as being near the extremes of the range of boiling-points of the terpenes as a class. In each case most of the hydrocarbon was converted into a resinous mass; torrents of sulphuretted hydrogen were evolved, and some cymene formed, the yield being about 30 per cent. with oil of turpentine, and 40 per cent. with hesperidene; in these cases evidently the cymene is formed by the reaction

$$C_{10}H_{16}+S=H_2S+C_{10}H_{14}.$$

In each case a trace of cymyl-sulphhydrate appeared to be formed.

V. Examination of various Cymenes.—The cymenes obtained as above described were carefully examined in the way detailed in last year's Report; all seemed to be identical with each other and with each of the eight kinds of cymene formerly examined as described in that Report. The following numerical values were obtained:—

A	Cymene from	absinthol and zinc chloride.		
B	,,	,,	,,	and phosphorus pentasulphide.
C	,,	,,	citronellol dibromide.	
D	,,	,,	,,	and pentasulphide of phosphorus.
E	,,	,,	cajeputol dibromide.	
F	,,	,,	,,	and pentasulphide of phosphorus.
G	,,	,,	hesperidene and pentasulphide of phosphorus.	
H	,,	,,	oil of turpentine and pentasulphide of phosphorus.	

	Boiling-points (corrected).	Specific gravity.	Specific refractive energy.	Specific dispersion.
A . .	175°–178°	0·8508	0·5652	0·0397
B . .	175–178	0·8622	0·5562	0·0413
C . .	175–177	0·8373	0·5620	0·0414
D . .	175–177	0·8555	0·5611	0·0407
E . .	176–177	0·8682	0·5510	0·0391
F . .	175–178	0·8455	0·5654	0·0406
G . .	176–177	0·8577	0·5626	0·0420
H . .	175–178	0·8534	0·5589	0·0404

Each of these specimens yielded terephthalic acid (averaging 40 per cent.) free from all trace of isophthalic acid, together with acetic acid free from all trace of higher homologues, by the action of chromic acid liquor.

The statements of Riban, that cymene is formed by the action of sulphuric acid on certain terpenes by the reaction

$$C_{10}H_{16}+H_2SO_4=2H_2O+SO_2+C_{10}H_{14},$$

have been verified; nevertheless the opinions expressed by the reporter in last year's Report that cymene may be isolated from certain hydrocarbons, *e. g.* oil of turpentine, by the polymerizing action of sulphuric acid have been found correct, it being found practicable to obtain a few per cents. of cymene from an old sample of turpentine-oil without any evolution of sulphur dioxide by careful manipulation. Orlowski also has recently obtained cymene from old oil of turpentine by continued fractional distillation, the mode of production of the cymene being probably first the absorption of oxygen and production of a camphor-isomeride like myristicol, or the analogous products obtained in small quantity by the action of chromic liquor on hesperidene and myristicene (British Association Report, 1872), and the subsequent breaking up of this product into water and cymene by continued distillation.

$$2C_{10}H_{16}+O_2=2C_{10}H_{16}O,$$
$$C_{10}H_{16}O=H_2O+C_{10}H_{14}.$$

Physical Properties of Essential-oil Constituents and Conclusions.

The following values were obtained for some of the other constituents of the essential oils examined:—

Terpenes.

Source.	Boiling-point (corrected).	Specific gravity.	Specific refractive energy.	Specific dispersion.
I. Citronellol and phosphorus pentasulphide . . .	175°–178°	0·8484	0·5570	0·0271
II. Citronellol and zinc chloride	170–180	0·8375	0·5400	0·0285
Oxidized substances.				
Absinthol	199–202	0·9128	0·4887	0·0234
Cajeputol	176–179	0·9207	0·4916	0·0251
Citronellol	200–205	0·870	0·5213	0·0289
,, ...	210–215	0·890	0·5176	0·0284
,, ...	225–230	0·887	0·5247	0·0301

Neither of the two terpenes were perfectly pure, I. being admixed with

a little cymene formed, as above stated, by the further action of the phosphorus pentasulphide, and II. yielding on combustion carbon 86·55, hydrogen 12·81, agreeing more nearly with the formula $C_{10}H_{18}$ than with $C_{10}H_{16}$, which requires carbon 88·24, hydrogen 11·76.

The physical properties of the three oxidized bodies agree tolerably well with the previous determinations.

The three specimens of citronellol are certainly not identical, for that with the lowest boiling-point rotated the polarized ray very strongly to the left. The intermediate one was without circular polarization, and that with the highest boiling-point showed a very little right-handed rotation.

The experiments made so far appear to indicate that many of the constituents of essential oils are closely related to the hydrocarbon cymene, this body being as it were the central form of matter from which terpenes and their derivatives of the forms $C_{10}H_{16}O$ and $C_{10}H_{18}O$ are all derived by various operations. As yet no reasonable prospect of success has appeared in the attempt to determine the different amounts of energy involved in those operations which yield isomeric products (*e. g.* in the operations whereby cymene is converted into camphor, myristicol, or absinthol, or into terebene, hesperidene, myristicene, &c.), one great difficulty in the way being the almost impossibility of obtaining absolutely pure homogeneous substances to operate upon.

Second Report of the Sub-Wealden Exploration Committee, the Committee consisting of Henry Willett, *F.G.S.,* R. A. C. Godwin-Austen, *F.R.S.,* W. Topley, *F.G.S.,* T. Davidson, *F.R.S.,* Prof. J. Prestwich, *F.R.S.,* Prof. Boyd Dawkins, *F.R.S., and* Henry Woodward, *F.R.S. Drawn up by* Henry Willett *and* W. Topley.

At the Meeting at Bradford the General Committee granted £25 in aid of the Sub-Wealden Exploration.

In August 1873, 290 feet, at a diameter of 9 inches, had been bored; and it was during the Bradford Meeting that Mr. Peyton, F.G.S., discovered *Lingula ovalis* in a core at the depth of 290 feet from the surface, indicating that at such a depth the boring was traversing Kimmeridge Clay. The slow rate of advance by the old system of boring was most disheartening; and at a Committee Meeting held 7th November, 1873, a definite tender having been obtained from the Diamond Rock Boring Company, it was accepted. This Company forthwith energetically commenced, ably performed, and completed it to a depth of 1000 feet on June 18th, 1874, at a cost of over £1400 for the additional 700 feet. The funds being by this time exhausted, at a Committee Meeting it was considered by the Members to be very important that the work *should not* be abandoned, and a Subcommittee (consisting of Professor Ramsay, LL.D., F.R.S., Director-General of the Geological Survey of England, John Evans, Esq., F.R.S., President of the Geological Society, and Prof. Joseph Prestwich, F.R.S., Ex-President of the Geological Society) was appointed to draw up a fresh appeal to the public for additional subscriptions; and Mr. Willett was urged to continue in office as Honorary Secretary and Treasurer. An interview also for Professor Ramsay and Mr. Willett with the Chancellor of the Exchequer was obtained by the Secretary of the Treasury, at which a grant of the public money in aid of the prosecution of this enter-

prise was solicited on the ground that it was of national importance, and that such an exploration had been recommended by a Parliamentary Committee (Coal Commission). In response a Treasury Minute was received to the effect that a maximum grant of £1000 would be recommended to Parliament, £100 of which is to be paid for every 100 feet bored beyond the first 1000 feet*. This recognition will, it is hoped, induce the Members of the General Committee of the British Association, at the Meeting at Belfast, to vote a liberal grant in aid on similar conditions; for under the most favourable calculation from £3000 to £4000 (including the cost of lining-tubes) will be needed ere 2000 feet (or Palæozoic strata) are reached.

No favourable opportunity having presented itself for observing the underground temperature, owing to the constant obstruction in the hole, these experiments are postponed until the bore-hole shall be lined.

The cost of the lining-tubes will approximate £500, towards which it is proposed to apply the grant which it is hoped will be made at Belfast.

Geological Report by W. Topley, F.G.S., Assoc.Inst.C.E., Geological Survey of England.

When the last Report upon the Sub-Wealden Boring was read at the Bradford Meeting of the Association, a depth of 300 feet had been attained, but no good fossils had been observed, and no certain information could be given as to the age of the beds traversed. The only point certainly established was that the higher beds of the boring, as well as the "Ashburnham Beds" of the neighbouring district, belonged to the Purbecks; but how deep the Purbecks extended, and what was the age of the underlying strata, were points then undecided.

We are still in some uncertainty as to the first point. Some imperfect specimens of *Estheria* (*Cyclas*) were observed by Mr. Peyton at about 100 feet from the surface, but no other fossils were noticed until the Kimmeridge Clay was reached. It is then only by the lithological characters of the intermediate strata that we can form any idea as to their age. A detailed section of the strata was given in the last Report, and specimens are still preserved at the boring. We should probably not be far wrong in assigning the beds down to the depth of 180 feet to the Purbecks, and regarding all between that depth and 290 feet as Portland. This classification places the gypsum and associated gypseous marls with the Purbecks, the sandy beds (sometimes almost a sandstone) and all the beds containing chert nodules with the Portland. Almost at the base of the Portland beds there are some veins of gypsum in pale shale. Some of the Portland sand or sandstone is rather greenish in colour.

At the last Meeting of the Association some specimens of the strata traversed were shown, including pieces of clay from the lower part. After the Report was read this clay was broken up by Mr. Peyton, who noticed some fragments of fossils which Prof. Phillips recognized as *Lingula ovalis*, a characteristic shell of the Kimmeridge Clay in England, but which was then unknown in the Boulonnais. Shortly after this, Mr. Peyton, in examining the cliffs near Boulogne, was fortunate enough to find there several examples of the same species.

* The grant was subsequently made by the House of Commons.

At the end of last year (1873), the contract with Mr. Bosworth (then the contractor) having expired, the work was handed over to the Diamond Rock Boring Company. By their system of boring long cores of strata are brought up, of which the mineral character and fossil contents can be ascertained with great accuracy*.

The boring is now (August 1874) 1030 feet from the surface, but the lowest 17 feet of core are not yet extracted. The strata from about 350 feet to 1013 feet have been examined with care, and many thousands of fossils or fragments of fossils have been observed. The greater part cannot be determined at all; in a large number of instances the genus only can be ascertained; but several hundred specimens can be with certainty assigned to their respective species. I have to thank Mr. Etheridge for much assistance in determining the fossils. Mr. G. Sharman and Mr. E. T. Newton have also kindly given me their aid. To Mr. Davidson I am also much indebted; he has looked over and named the Brachiopoda, and has drawn specimens of *Lingula ovalis* and *Discina latissima* from the boring for the forthcoming Supplement to his 'Monograph on the Brachiopoda,' published by the Palæontographical Society.

The greater part of the cores have been broken up on the spot, and the fossils sorted out for more detailed examination in London. In this task I have often had the assistance of Mr. Willett and Mr. Peyton. Some of the cores have been broken up and examined by Mr. Willett at Brighton.

The greater part of the strata traversed below 290 feet is clay; generally it is rather calcareous, and from 640 feet downwards there are bands of cement-stone. The higher part of the Kimmeridge Clay is rather sandy, but no beds at all approaching a sandstone in character have been observed in that formation. The middle and lower part of the Kimmeridge Clay contains much petroleum; at some horizons there is so much that the shale will burn. The petroleum shales of the lower part are generally very fossiliferous; but those of higher portions are often very bare of life.

The Oxford Clay often contains much petroleum, and it also is very fossiliferous.

Generally in England the Coral Rag comes between the Kimmeridge and Oxford Clays; this is also the case in the Boulonnais. Occasionally, however, in England the two clays come together without the intervention of the Coral Rag. This appears to be the case in the boring. An Oxford-Clay fossil (*Ammonites Sedgwickii*, Pratt) was observed at 972 feet from the surface. Below this several imperfect specimens of ornate *Ammonites* occur. A good example of *Am. Jason*, Rein., occurred at 990 feet, and *Am. Lamberti*, Sow., at 1000 feet. A fragment of *Pollicipes* (probably *P. concinnus*, Sow.) occurred at 993 feet, and a doubtful *Gervillia* at 998 feet. *Pollicipes* and *Gervillia* both occur in the Oxford Clay, but I believe have not yet been recorded from the Kimmeridge Clay of England.

With regard to the exact point at which the Kimmeridge Clay leaves off and the Oxford Clay begins there is some doubt. We must be guided in this case by palæontological evidence, assigning all those strata to Oxford Clay which contain fossils only hitherto known from that formation, and doing the same with the Kimmeridge Clay. We have seen that an Oxford-Clay fossil (*Ammonites Sedgwickii*) occurs at 972 feet. *Gryphæa virgula*, Defr., a Kimmeridge-Clay fossil, occurs at 950 feet; this is therefore Kim-

* It should be mentioned that other methods of boring (in holes of small diameter) succeed in extracting solid cores of strata; but probably no other would give such long and unbroken cores.

meridge Clay. Between 950 feet and 972 feet we have no good palæontological evidence. The fossils which occur here are the following:—

Avicula. 952 feet.
Cardium striatulum. 951, 952 feet.
C. striatulum, var. lepidum, *Sauv. et Rig.* 967 feet.
Nucula. 951, 952 feet.
Lingula, resembling L. ovalis, *Sow.*
Ostrea. 953, 965 feet.
Pecten arcuatus, *Sow.* 952 feet.
Astarte (a smooth species). 956 feet.
Thracia depressa. 965 feet.
Ammonites biplex? 957, 969 feet.
Tornatella. 967 feet.

All of these (excepting perhaps *Tornatella*) occur in the Kimmeridge Clay. *Thracia depressa* is very characteristic of the Kimmeridge Clay, but it also ranges downwards to the Great Oolite. It occurs at 965 feet in a soft dark clay, which ranges with much the same characters from 963 feet to 976 feet; and as it is this clay which (at 972 feet) contains *Ammonites Sedgwickii*, we can hardly take a boundary at this point. Above this there are 5 feet of unfossiliferous sandy clay, and then come 8 inches of hard, dark grey, heavy, and sandy clay, with much petroleum. Just above this there is a little hard sandy clay, containing a layer of a smooth form of *Astarte*, and above that some soft dark clay.

If we have to fix upon a definite line, it would probably be advisable to take it just below the soft clay last named, at 956 feet. One reason for doing this is, that at 965 and 972 feet there are sometimes well-marked signs of a dip across the bore-hole; sometimes this is shown by the layers of fossils lying obliquely; and at 965 feet it was very distinctly shown by a layer, 1 inch thick, of light-coloured clay; the dip of this was about 10°.

The dips in these places are not owing to an unconformity, because the layers of fossils just above and just below are quite horizontal. But nothing of the sort has been observed in the true Kimmeridge Clay; and this is one reason, though a very slight and untrustworthy one, for taking the boundary above these beds. Higher up in the Kimmeridge Clay there have been cores breaking obliquely, which at first look like inclined strata; but in all such cases careful examination has shown that these appearances are due to thin veins of carbonate of lime.

It was stated above that *Gryphæa virgula* is solely a Kimmeridge-Clay shell. In Damon's 'Geology of Weymouth' it is stated that this shell occurs in the Oxford Clay of that district; but in the Atlas of Plates which accompanies the Handbook, a figure is given as *Gryphæa* (*Ostrea*) *virgula*, which is certainly not that shell, nor one in any way resembling it. We must therefore conclude that the true *Gryphæa virgula* has not yet been found in the Oxford Clay of Weymouth.

In the Sixth and Seventh Quarterly Reports, *Modiola pectinata*, Sow., appears amongst the lists of fossils. Further examination of these shells has shown that, although they resemble the shell figured under that name in Phillips's 'Geology of Oxford,' they are really distinct from the shell figured by Sowerby. Sowerby's shell is really a *Mytilus*, and as such he described it (*Mytilus pectinatus*); whilst the shells of the boring are certainly *Modiolæ*. They somewhat resemble the *Mytilus Morrisii* of Sharpe, originally figured from specimens from the Sub-Cretaceous limestone of Portugal, but which also occurs in the Kimmeridge Clay of Wootton Bassett and in the Boulonnais. They are, however, distinct from this, and must be regarded as a new species. In the Museum of Practical Geology there is an unnamed specimen of this species from the Kimmeridge Clay of Hartwell.

Dr. Lycett has kindly examined some specimens of *Trigonia* from the boring. Amongst them he recognized a young form of *Trigonia Juddiana*,

Lyc., and another species which is apparently new. We have also observed some specimens of a small elongated ribbed *Astarte* which appears to be new.

In the Sixth Report *Astarte aliena*, Phil., was mentioned, and in the Seventh Report *Astarte Autissiodorensis*, Cotteau. More careful examination of a greater number of specimens has shown that these names cannot be retained. The small ribbed *Astartes* of the boring vary a little in size and in the number and character of their ribs; but it seems preferable to regard them all as slight varieties of the *Astarte Mysis* of De Loriol. The ribs are always less in number than in the true *Astarte Autissiodorensis.*

Considerable difficulty has occurred in naming the *Cardiums*. The French palæontologists have founded several species upon what most English palæontologists would regard as simply varieties of the original *Cardium striatulum* of Sowerby. In the higher part of the boring the *Cardiums* are large, and may with tolerable certainty be referred to *C. striatulum*. In the lower part, both in the Oxford and Kimmeridge Clays, the shells are smaller. MM. Sauvage and Rigaux have described similar shells from the Kimmeridge Clay of the Boulonnais as *Cardium lepidum*. It may perhaps be advisable to retain this name, regarding the shell, however, as a variety of *C. striatulum* and not a distinct species.

The following is a list of all the fossils hitherto observed. Those *species* which occur in both the Oxford Clay and Kimmeridge Clay are marked with an asterisk.

List of Fossils from the Kimmeridge Clay.

Serpula. Attached to *Cardium* at 842 and 847 feet.

Cidaris Boloniensis, Wright. At 397 feet.

Discina Humphrisiana, Sow. At 569 and 570 feet.
D. latissima, Sow. Common.
**Lingula ovalis*†, Sow. Common.

Arca. Species not determined. Tolerably abundant.
Avicula. Rather rare. 380, 420, 438, 456, 952 feet.
Astarte Hartwellensis, Sow. It is not easy to distinguish fragments of this shell from *Thracia depressa*.
A. ovata, W. Smith. At 570 feet.
A. Mysis, D'Orbigny. Common.
Astarte, new sp. 463 feet.
**Cardium striatulum*, Sow. Common, especially in the higher part.
**C. striatulum*, var. *lepidum*, Sauvage et Rigaux. 813, 814, 817, 818, 898, 913, 925 feet.
Corbula. 784 feet.
Gryphæa nana, Sow. 430, 900, 902 feet.
G. virgula, Defr. Several crushed specimens at 913 feet; a perfect form at 950 feet.
Hinnites? 478 feet.
Leda. 494 feet.
Leda, allied to *L. Dammariensis*, Duv. 415, 511 feet.
Lima. 380, 804 feet.
Lucina. 415, 465, 493 feet.

† There is a *Lingula* in the Oxford Clay, which is distinguished from *L. ovalis* only by its size, it being always small, whilst *L. ovalis* varies much in size. Mr. Davidson proposes to distinguish the Oxford-Clay shell by a new specific name.

Modiola, n. sp. Common down to 782 feet.
Myacites. 380, 388, 415 feet.
Nucula. 388, 951, 952 feet.
Opis. Depth uncertain.
Ostrea deltoidea, Sow. 452 ?, 470, 478 feet.
O. Thurmanni, (var. of) Etallon. 719, 794 feet.
Ostrea, ? sp. Numerous fragments.
Pecten arcuatus, Sow. 388, 396, 418, 480, 492, 493, 496, 576, 952 feet.
Pecten. A form with coarse ribs.
Pholas compressa, Sow. ? 526 feet.
Pholadomya. Fragments of large forms at 725 and 789 feet.
Tellina. 910 feet.
**Thracia depressa*, Sow. 397, 415, 437 feet.
Trigonia Juddiana, Lyc. (young form of). 926 feet.
T. Pellati, Mun. Ch. 376 feet.
Trigonia, ? new species. 402 feet.

Alaria. Rather common.
Cerithium. 789 feet.
Pleurotomaria reticulata, Sow. 830, 900, 913 feet.
Pleurotomaria, ? sp. (probably *P. reticulata*). 726, 741, 898, 902 feet.
Turbo. 783.

Belemnites. Rather common.
**Ammonites biplex*, Sow. Common.

Hybodus-tooth. Depth uncertain.
Fish-vertebra. 492, 550 feet.

List of Fossils from the Oxford Clay.

Pollicipes concinnus, Sow. 993 feet.

**Lingula* (? *L. ovalis*). 988 feet.

Arca. 976, 991, 992, 995, 996, 998, 1000 feet.
Avicula. 993, 1000 feet.
Astarte. 969, 976, 990, 993 feet.
**Cardium striatulum*, Sow. 979 feet.
**C. striatulum*, var. *lepidum*, Sauv. et Rig. 967, 977, 979, 990, 993, 999, 1001 feet.
Corbula. 995, 996 feet.
Gervillia. 998 feet.
Macrodon. In hard sandy strata at 1013 feet.
Ostrea. 965, 990, 994, 996, 1004, 1612 feet.
Tellina. 990 feet.
**Thracia depressa*, Sow. 965 feet.

Alaria. 990 feet.
Cerithium. 998 feet.
Tornatella. 967, 1003 feet.

**Ammonites biplex*, Sow. 957, 969, 972, 991, 998 feet.

Ammonites Jason, Rein. 990 feet.
A. Sedgwickii, Pratt (var. of *A. Jason*). 972 feet.
A. Lambertii, Sow. 1000 feet.
Ammonites, ? sp. (with tubercles). 979, 998 feet.

Fish. 1001 feet.
Hybodus. 1004 feet.

On the Recent Progress and Present State of Systematic Botany. *By* George Bentham, *F.R.S.*

[A communication ordered by the General Committee to be printed *in extenso*.]

It is now some years beyond half a century since I took up the pursuit of systematic botany—at first as a mere recreation, rather later as a study either subservient to or as a diversion from others which my then social position rendered more important, but for the last forty years as the main occupation of my life. During that long period the science has undergone various vicissitudes. At one time generally regarded as constituting the whole or nearly the whole of botany, subsequently reduced by some to a mere technical cataloguing of names, it became the fashion, especially among physiologists, who arrogated to themselves the exclusive title of scientific botanists, to sneer at it as a trivial amusement; it has now again vindicated its importance, especially since, by the promulgation of the great Darwinian theories, it has become absolutely necessary to include in it, not only the life-history and distribution of races, but also the results at least of the investigations of physiologists and palæontologists, whilst physiologists themselves have but too frequently been led astray by their neglect of the labours of scientific systematists. Having in my early days personally conversed with one of Linnæus's active correspondents (Gouan of Montpellier), having received many useful hints on the method of botanical study from the great founder himself of the Natural System (Antoine Laurent de Jussieu), having been honoured with the intimacy of the chief promoters and improvers of that system (Auguste Pyrame De Candolle, Robert Brown, Stephan Endlicher, John Lindley), having enjoyed the friendly assistance either personally or by correspondence of almost every systematic botanist of note of this nineteenth century (whether followers or, in earlier days, antagonists of the Jussieuan methods), I had from the first taken some part in the controversies which ensued, and always watched them with an interested eye. And now at the close of my career I had sketched out a review of the position this, my special branch of the science, has occupied in relation to the others for my valedictory address to the Linnean Society. My premature resignation of the Presidency having rendered unnecessary the drawing-up of that address, I have put my notes into a form which I have thought might not be unacceptable to the Association, as some compliance with the request made to me at its Meeting at Cambridge in 1833.

Before the days of Linnæus, the attempts to scale and explore the steep and rugged acclivities of the Parnassus of Science on the side of Natural History, and especially in the district of Systematic Botany, had been many, but vague and unsuccessful. Some general ideas of the direction to be

followed had, indeed, been formed by Ray, and after him by Tournefort, Allioni, and others of undoubted eminence; but it was reserved for the master-mind of the immortal Swede to mark out a clear, safe, and definite road along the first great ascent, and to fix on its summit, by the establishment of genera and species upon sound philosophical principles, a firm stage to serve as a basis and starting-point for further progress and exploration. Such further progress under the guidance of the same principles was indeed contemplated and to a certain degree sketched out by Linnæus himself, but the territory forming the next acclivity was too little known to disclose the best paths for ascending it. Among the eight or ten thousand species known to Linnæus, chiefly from the northern hemisphere or from the Cape of Good Hope, a sufficient number of genera were exhibited to him in their entirety to enable him to fix the relations of genus and species; but of the higher groups, the orders or natural families, too large a proportion were as yet undiscovered or were too sparingly represented to encourage any immediate attempt to define them. A further knowledge of the territory was necessary in order to clear the ground for its regular ascent, and yet it was necessary to ascend in order to effect its survey; as a temporary assistance, therefore, Linnæus devised the scaffolding, known under the name of the sexual system, with its artificial and easy though frail ladders, the twenty-four classes and their sudsidiary orders.

The progress was now wonderfully rapid. A very few years doubled the number of plants known, and after the commencement of the present century new discoveries and more accurate studies of those previously known were being published in all parts of Europe in an increasing ratio. It was, however, rather earlier, and not long after the death of Linnæus, that Antoine Laurent de Jussieu, following in the footsteps of his uncle Bernard, with a methodical mind yielding but little to that of the great Swedish master, having all the advantages of the additional materials at his disposal, and having to start from the elevated platform so firmly established by his predecessor, was enabled, in his 'Genera Plantarum' (begun in 1778 and finally published in 1789), to carry the high road up the next rising, marking it out perhaps at first rather vaguely, but upon principles so sound that it was warmly taken in hand by the French school in the first instance, soon to be followed up in this country, and later and less willingly in Germany. Among the earliest and most important contributors to the perfecting the work were Robert Brown and the elder De Candolle; and their labours had already been sufficiently advanced to enable me, when I first came upon the stage, to avail myself of the road thus established and ascend with ease to the higher platform. The great Linnean thoroughfare to species and genera had long been universally followed, and my apprenticeship to the science, from 1817 to my first botanical publication in 1826, was entirely under the guidance of De Candolle's 'Flora' and 'Théorie;' so that I had no occasion to make use, or even to take any notice, of the Linnean scaffolding and ladders. I never learnt the twenty-four classes till after the publication of my 'Catalogue des Plantes indigènes des Pyrénées et du Bas Languedoc.' Easy as they were supposed to be, I found, for purposes of reference, alphabetical indexes still easier.

Towards the close of this same year (1826), in which I had thus entered my name in the roll of working botanists, I returned to England after a twelve years' residence in France; and although logic, law, and law-making were at first the chief subjects of my studies and publications, I gradually gave up more and more time to botany, and having spent two vacations

among the naturalists of Germany, I had by the year 1832 become acquainted not only with the principal continental botanists, but also with the practical working of the botanical establishments of Paris, Berlin, Vienna, Munich, and Geneva; and as this was a period when the gradual substitution of natural to artificial systems had given a general impulse to the scientific study of plants, I take this year as the starting-point for comparing the state of systematic botany with that of future periods.

In France, under the guidance of De Candolle of Geneva, and of Brongniart, the younger Jussieu, and other Professors of Paris, it was now universally taught, and it had become generally acknowledged, that the main object of systematic botany was not the finding out the name of a plant, but the determining its relations and affinities, the making us thoroughly acquainted with its resemblances and differences, with those properties which it possessed in common with others or which were peculiar to itself, whether these properties consisted in outward form, inner structure, physical constitution, or practicable applicability to use, all of which had to be taken into account in the formation of orders, genera, and their subdivisions. As text-books, De Candolle had developed his 'Théorie' into the five volumes of his 'Cours de Botanique' ('Organographie Végétale,' two vols., 1827, and 'Physiologie Végétale,' three vols., 1832), while Richard, in the successive editions of his 'Éléments de Botanique,' then in general use by teachers of the science, was substituting an elaborate exposition of the natural orders for the somewhat modified Linnean classes he had in the first instance adopted; and for practical use, although De Candolle's admirable 'Flore Française' was already out of print, Duby's synopsis of it and a few local floras drawn up under the natural method had expelled from the market all technical works which adhered to the sexual classification. For the general botanist, De Candolle's 'Prodromus' had already reached its fourth volume, describing under the natural arrangement about 19,000 species, or nearly one third of those then known *.

In England considerable progress had also been made in the substitution of the scientific instead of the technical arrangement of plants for study, but only among the more advanced followers of the science. Owing in a great measure to the influence and persevering labours of Sir James Smith, whose possession of the Linnean collections and long Presidency of the Linnean Society gave him great and generally acknowledged authority in the country, the cataloguing of plants under the twenty-four classes was still adhered to in our botanical schools and examinations, and in the standard British floras as well as in all local ones. But this was not to be of long duration. The great advances made by Robert Brown, although better known on the Continent than at home, were beginning to have their influence in England also. The example and teaching of Sir William (then Dr.) Hooker, whose vast collections and library had already, from the liberal use he made of them, become of national importance, had caused the natural method to be regarded as the only one for illustrating exotic botany and for the useful arrangement of herbaria. Lindley had commenced that series of works which more than any others tended to that final acceptance of the natural method in this country which it had obtained in France. The first edition of his 'Introduction to the Natural System' was published in 1830; and he was much

* For further details on the origin and progress of this great work I may refer to an article I contributed to the 'Natural-History Review' for October 1864, and to that recently published by Alphonse de Candolle in the 'Bibliothèque de Genève,' entitled "Réflexions sur les Ouvrages généraux de Botanique descriptive."

engaged in the preliminary labour of a 'Genera Plantarum' he contemplated. Monographs also of individual natural orders or large genera which De Candolle always strongly recommended, not only as the best exercise for young botanists, but as the best means of promoting the science for those whose circumstances prevented their undertaking more general investigations, were in some instances being prepared in England as on the Continent. Hooker, Greville, Arnott, and others had devoted special works to Ferns and Mosses; Lindley had made considerable progress with his 'Genera and Species of Orchideæ,' and at his suggestion I had taken up the Labiatæ. Even for the British flora S. F. Gray's 'Natural Arrangement' and Lindley's 'Synopsis' were intended to bring the natural orders into use by our local botanists; but owing to defects in form and to the want of any artificial Clavis, neither of these works was calculated to overcome the prejudices then prevailing in favour of the Linnean classes.

In Germany the progress had been slower. The country abounds in those plodding minds which revel in the working out minutiæ of detail, and, to find their way, are satisfied with a sexual, alphabetical, or any other artificial index, as well as in pure speculators, who, in developing the conceptions of their brain, will not be bound by any system. The advantages of the natural method were long in overcoming the force of habit, kept up as it was by the number of works which the German press supplied for the use of collectors and technical botanists. The most important of these took the form of new editions of Linnæus's 'Systema Vegetabilium' or of his 'Species Plantarum.' The last two of these had a very general circulation in the botanical world: Sprengel's, completed in four volumes from 1817 to 1820, would have been useful from its compactness had it been a conscientious compilation, and actually served for the arrangement of herbaria in the charge of mere librarians *; but it was so carelessly and recklessly worked out as to be soon rejected by all true botanists who attempted to use it. Roemer and Schultes's 'Systema,' continued through eight volumes from 1817 to 1830, was the result of great labour and was generally accurate in detail, and would have been really useful had it been brought to a conclusion within a short time. But by the time it had reached the end of Hexandria, the progress of De Candolle's 'Prodromus' had even in Germany driven it out of the market, leaving it, in its incomplete state, nothing but a long succession of disconnected genera, the confusion of which was still further increased by a series of 'Mantissas' and first and second Additamenta to 'Mantissas.' Neither the ability of the younger Schultes, the author of the last two and best volumes (Hexandria), nor the arguments of Roemer (who in the preface justified the use of the sexual system, first on the authority of Linnæus, secondly because it was easy, and thirdly because, like nature, it never changed) could any longer sustain the crumbling fabric. The Natural Orders were becoming generally taught, and Bartling, in his 'Ordines Naturales Plantarum,' 1830, had proposed one of those speculative rearrangements of the Jussieuan and Candollean Orders which have since been so frequently indulged in to so little purpose. But as yet there was no flora of the country or other practical work calculated to place the natural or scientific method within reach of the beginner.

Other more distant countries showed still fewer outward signs of the spread of the philosophical teaching of botanical systems, which, however, through the influence especially of French works, was gradually gaining ground in

* Even at Paris the rich herbaria of Delessert were to the last arranged according to Sprengel, to the thorough disgust of all working botanists who had to consult them.

Sweden, Russia, and North America, whilst in Southern Europe Spain and Italy, which during the preceding half century had produced so many eminent botanists in various branches, seemed now disposed to limit themselves to local floras and the sexual classes.

We may take as the next period in the progress of systematic botany the seventeen years that elapsed from 1832 to 1859, during which the advance had been wonderfully successful. The change from the technical to the scientific study of plants, which during the preceding period had been working its way through so many obstacles, was now complete. The Linnean platform, established on the relations of genera and species, had now been so long and so universally adopted as the basis or starting-point, that the credit due to its founder was almost forgotten in the triumphant destruction of the sexual scaffolding he had erected for the ascent of the higher stages, and now completely superseded by the progress of the Jussieuan roads, although it was chiefly by the consistent following out the principles laid down by Linnæus himself that the change had been effected. No would-be botanist was allowed any longer to eschew the labour of the methodical study of plants, or to indulge in the belief that their technical sorting constituted the science. At every stage he was taught that plants must be grouped upon a philosophical study of their affinities, whether morphological, structural, or physiological. The natural orders, as well as genera, were exhibited to him in every work prepared for his use. Their exposition formed part of the admirable text-books of the De Candolles (father and son), Adrien de Jussieu, Lindley, and others; Endlicher's 'Enchiridion' and, above all, Lindley's 'Vegetable Kingdom' exhibited the rich stores of knowledge disclosed by their study. As systematic guides, Endlicher's 'Genera Plantarum' was complete, and De Candolle's 'Prodromus' for Dicotyledons and Kunth's 'Enumeratio' for Monocotyledons were far advanced, the gaps being also partially filled up by numerous monographs of various degrees of merit; whilst in Cryptogams the works of Hooker, Mohl, Mettenius, Montagne, Fries, Tulasne, Berkeley, Agardh (father and son), Harvey, Thuret, Kützing, and many others were already showing that for their discrimination and study it was no longer sufficient to rely upon outer characters alone, but that their inner structure and physiological changes must be taken into account; and monographs or "species" of Ferns, Mosses, Hepaticæ, Lichens, Fungi, and Algæ, arranged upon principles more or less philosophical, were prepared for the use of the student in these several branches. For more local botanists and amateurs most European countries, and a few distant ones, had now their standard floras in a more or less advanced state, arranged according to the natural method, the more important of which I shall presently have occasion to refer to.

It would seem, therefore, that at this advanced stage of our progress the guide-posts indicative of the principal paths had become so firmly established, the principles upon which plants should be scientifically classed so clearly laid down and so far carried into practice, that little remained to be done towards completing the survey of the territory, towards a general distribution of species according to their natural affinities, beyond the more accurate delineation of details and the interpolation of newly discovered species, and that the systematic botanist could already look towards that summit, upon reaching which his labours in aid of the general advance of the science might come to a close. But there was a rock a-head which had long been looming in the distance, and which on a nearer approach opposed a formidable obstacle, to most minds apparently insurmountable. What is a species?

and what is the meaning of those natural affinities according to which species are to be classed? were questions which in 1859 it was generally thought vain to discuss, or the answers to which, given to us by doctrinal teachers, unsupported by or independent of facts, it was considered as sacrilegious to doubt. We were taught, and some may still believe, that every species, such as we now see it, was an original creation, perpetuated through every generation within fixed limits which never have been and never will be transgressed. We were less authoritatively told that resemblances of different species were owing to their having been formed upon one plan variously modified. To the question why they were so modified, the ready answer was, such was the will of the Creator; and in order not to suppose that that will was influenced by mere caprice, it was suggested that the modifications were either to suit the plant to the circumstances it was placed in, or to remedy defects in the original plan, or we were simply told that the subject was beyond our powers of comprehension *.

One consequence of this apparent impossibility of proceeding further in the investigation of the causes of affinities and of this necessity of taking species as separate creations in enormous numbers, with resemblances and differences in endless variety according to the inscrutable will of the Creator, was the encouragement it gave to arbitrary classifications and interminable disputes as to the limits of individual species. It was, indeed, generally admitted that plants should be arranged in genera, orders, &c., in groups of higher and higher grades according to the importance of the characters they had in common, and that the test of species was the persistence of its characters through two or more generations; but there were no means of estimating the importance or value of characters except by such vague standards as the number of species in which they had been observed to prevail, no means of determining what degree of variation and persistence actually distinguished the species from the variety. The botanist who affirmed that *Rubus fruticosus*, *Draba verna*, or *Sphagnum palustre* were each one very variable species, and he who maintained that they were collective names for nearly four hundred, for at least two hundred, or for some twenty separately created and invariably propagated species, had each arguments in their favour to which no definite reply could be given; and systematic botany was in too many cases beginning to merit the reproach of German physiologists, that it was degenerating into an arbitrary multiplication and cataloguing of names and specimens, of use to collectors only, and serving as impediments instead of aids to the extension of our scientific knowledge of the vegetation of the globe.

It is true that long before the period under consideration some indications by which this great obstacle to further progress might be surmounted had

* In my frequent intercourse during the above period with foreign botanists, I heard more than one German Professor affirm that a type-form was created for each natural order (the common clover, for instance, being that for Papilionaceæ), that Nature set to work to modify this type-form in framing species of a more complicated structure, till, tired of the exertion, she next produced new species by the simple omission of some of the complications. A French botanist of great eminence, to account for the number of plants in cultivation which are not known to exist in a wild state, observed that we could not suppose that man would have been created without a simultaneous creation of plants for him to cultivate for food, quite independent of the wild vegetation which existed before him for the food of animals. And many other still wilder theories were propounded to account for facts inconsistent with the presumed independent creation and absolute fixity of species. The best authorities went no further than defining affinity as correspondence of characters, physiological or structural, and estimating the value of characters and the importance of peculiarities or modifications of character according to their known connexion with the phenomena of life.

been vaguely given, and the theory of a common descent of modern species had been broached, or generally proposed as a solution of some of the difficulties; but not in a manner sufficiently plausible to overcome the prejudices against following up any such track, nor supported by facts and observations sufficient to awake the attention of the more anxious pursuers of the science. It was reserved for the publication of the 'Origin of Species' in 1859 to mark out a practicable path by which the higher summits might be attained. The doctrine of evolution of species, according to laws originally fixed, instead of arbitrary intervention upon each and every occasion, was in this remarkable work clearly traced out, supported by powerful arguments, and founded upon facts and observations the accuracy of which no one could doubt; and a way was thus opened up to a pinnacle, which in a wonderful degree enlarged the range of vision of those who had the courage to follow its propounder up the giddy height. It was immediately and successfully taken to by several of the most eminent of our naturalists accustomed to philosophical deductions from ascertained facts; it was blindly accepted, but misused, by some German and Italian speculators, who, in their hurry to adopt Darwinism before they well understood it, and in their eagerness to go beyond the point to which the road had been securely marked out by the author, or to diverge into by-paths which led to precipices and pitfalls, added to the alarm of the timid; whilst it was not only shunned, but denounced as fraught with the utmost danger by the great majority who were accustomed to place tradition above reasoning. We systematists hesitated at first to advance in a direction so contrary to that which we had determinately followed for so long a period; but after a careful study of the facts and arguments upon which the new course was founded, and of the guide-posts which had been set in it, we most of us have felt but little doubt of its safely leading us over difficulties, which we had so long reckoned as insurmountable, into a vast and entirely new field of observation, calculated to give a stability to the results of our labours, of which we had hitherto formed no conception. The last of the eminent observers of nature who persistently maintained the independent creation and absolute fixity of species (the late distinguished Professor Agassiz) has recently gone from among us; and it may now be given as a generally received doctrine, that all natural methods must be founded on affinities as dependent on consanguinity. Fifteen years have sufficed to establish a theory, of which the principal points, in as far as they affect systematic botany, may be shortly stated as follows:—

That although the whole of the numerous offspring of an individual plant resemble their parent in all main points, there are slight *individual* differences between them.

That among the few who survive for further propagation, the great majority, under ordinary circumstances, are those which most resemble their parent, and thus the *species* is continued without material variation.

That there are, however, occasions when certain individuals with slightly diverging characters may survive and reproduce races in which these divergences are continued even with increased intensity, thus producing *Varieties*.

That in the course of an indefinite number of generations circumstances may induce such an increase in this divergency, that some of these new races will no longer readily propagate with each other, and the varieties become *New Species*, more and more marked as the unaltered or less altered races, descendants of the common parent, have become extinct.

That these species have in their turn become the parents of groups of species, i. e. *Genera*, *Orders*, &c., of a higher and higher grade according to the

remoteness of the common parent, and more or less marked according to the extinction or preservation of unaltered primary or less altered intermediate forms.

As there is thus no difference but in degree between a variety and a species, between a species and a genus, between a genus and order, all disputes as to the precise grade to which a group really belongs are vain. It is left in a great measure to the judgment of the systematist, with reference as much to the use to be made of his method as to the actual state of things, how far he should go in dividing and subdividing, and to which of the grades of division and subdivision he shall give the names of Orders, Suborders, Tribes, Genera, Subgenera, Sections, Species, Subspecies, Varieties, &c., with the consequent nomenclature. In the limitation of his orders, genera, species, &c. he must carefully observe those cases where the extinction of races has definitely isolated groups having a common parentage; and in other cases where the preservation of intermediate forms has left no such gaps, he is compelled to draw arbitrary lines of distinction wherever it appears to be most convenient for use. In the pre-Darwinian state of the science we were taught, and I had myself strongly urged, that species alone had a definite existence, and that genera, orders, &c. were more arbitrary, established for practical use, and founded on the combination of such characters as appeared the most constant in the greater number of species, and therefore the most important; we must now test our species as well as genera or other groups, by such evidences as we can collect of affinity derived from consanguinity.

In valuing these evidences, in estimating the comparative value of characters, a new difficulty has arisen, that of distinguishing the two classes of characters to which Professor Flower has appropriately given the names of *essential* and *adaptive*, the former the result of remote hereditary descent, the latter the more recent effect of external influences. This distinction is often the more difficult, as the essential ones are often only to be found in embryos, in the early stages of organs, or are merely indicated by slight rudiments requiring close observation to detect them; whilst the adaptive ones, of comparatively small systematic importance, are often developed in external form, in ramification, spinescence, foliage, &c., and are the most striking to the eye. One consequence is, that the systematist of the present day sees more and more the necessity of preparing a double arrangement of his genera, species, and other groups—a natural one according to the best evidences of affinity for the purpose of scientific study, and an artificial clavis by which the student can be led to identify genera or species by the more readily observed characters, which may only form part, or be but chance accompaniments, of the essential ones. The greatest change, however, which the adoption of the doctrine has effected in the methodical study of plants is the having rendered it necessary, in the case of every genus or other group, to take into account and specially to estimate the value of all the characters observed—no one can be taken as so absolute as to obviate the need of considering others, no one can be passed over as theoretically worthless; and whilst this adds immensely to the labour of the systematist and to the calls on his judgment, it gives equal increase to the value of the results obtained.

The principal works through which the systematic botanist contributes to the scientific study of the vegetable kingdom are:—1. General treatises or descriptive reviews of the natural orders (Ordines Plantarum); 2. Methodical enumeration and descriptions of genera (Genera Plantarum); 3. Methodical enumeration and descriptions of species (Species Plantarum); 4. Monographs of separate orders or genera, subgenera or species; 5. Floras of separate

countries or districts; 6. Detached and miscellaneous specific descriptions. Before considering how far the works now complete or in progress answer our requirements under each of these heads, a few general remarks are suggested with regard to the languages in use.

In the pursuit of my systematic studies, and especially in the preparation of my reports and addresses to the Linnean Society, I have had to consult or refer to botanical publications in no less than fifteen different languages *. This, to say the least of it, entails the use of a series of dictionaries which but a small number of botanists can have access to; and many an important observation or discovery recorded remains, for this reason alone, long unknown to the general botanist. That works intended for the use of the beginner or local amateur, or exclusively teaching the well-known botany of a particular country, should be in the familiar language of the country, is a rule that every one will admit the expediency of; but for purely scientific treatises and technically descriptive works which all botanists may have to take cognizance of, and for which the commercial demand may be too limited to ensure their translation into various languages, it is essential that that one should be selected which is most likely to be intelligible to the greater number of students of all countries. With this view Latin had been very generally adopted during the last and the early portion of the present century. It was taught in all European schools, and served even as a vehicle for general interchange of ideas between the votaries of science of different countries where the study of modern languages was exceptional; and even now it is found to be the best suited for technical diagnoses and descriptions from its concise character and from its susceptibility of being subjected to technical forms, without jarring upon the conventionalities of living languages in familiar use. Every botanist must still, therefore, learn to read, and every descriptive botanist to draw up, these Latin formulæ, notwithstanding the character of dog-Latin which the scholar may be disposed to charge them with; but general descriptions, treatises, and discussions require a language more thoroughly understood and in familiar use for other purposes. A classical education is now much less common than it was, and almost unknown in some countries where science is eagerly pursued. Modern languages are, on the other hand, much more frequently taught for general use; and there are three which at the present day every botanist ought to understand, and in one of which he ought to be able to write—all three having a rich literature in every branch to repay the labour of learning them, independently of science; these are, French, English, and German.

French has long been considered the one among modern languages forming the nearest approach to a common one; it is easy, comparatively simple in construction, not overburdened with redundant words, and, above all, is readily broken up into short phrases, an invaluable qualification for clearness of methodical exposition. It has long been the recognized diplomatic language, and the first foreign one taught in most European schools; and although within my own recollection national animosities may have from time to time thrown it into disfavour in Germany and Eastern Europe, yet it always appears to recover its prestige there in general society. At the meetings of the botanists of various nations congregated at Florence last May it was the general medium of intercourse, although the Frenchmen present were in a very small minority. And in every branch of science or literature to which I have paid more or less attention, it possesses more

* Latin, English, French, German, Dutch, Danish, Swedish, Russian, Polish, Bohemian, Hungarian, Portuguese, Spanish, Italian, and modern Greek.

instructive elementary works, more readily intelligible treatises and clear expositions of abstruse subjects, than any other language I am acquainted with. For the botanist, therefore, as well as for all naturalists, its study is still, and I believe will long remain, of first-rate importance.

The English language has of late years been recommended by more than one continental naturalist for general adoption as a vehicle for international scientific intercourse. It partakes of some of the advantages of both the French and the German. Though less brilliant, it offers more variety than the former, it is less involved than the latter, and it appears to be capable of giving more precision and force to argument than either. It is now the national language of the largest proportion of the civilized population of the globe, and its use continues steadily to spread out of Europe generally, and to a certain extent among European naturalists and other educated classes, especially in eastern and northern Europe. They begin to admit the necessity of consulting our untranslated treatises and memoirs, and our German and east European botanical correspondents, at least, accept English letters as readily as French. In southern Europe French is still much more generally understood; but even there the objections to the extended use of our language for botanical works have now, I believe, lost much of their force.

The German is a more difficult language, much more difficult, indeed, for the Latin nations of southern and western Europe than for ourselves. Its construction is involved, its extraordinary copiousness occasions a strain upon the memory; but it affords great facilities for giving expression to minutely distinguished details, whether of fact or of thought. It may thus frequently give greater solidity to their theoretical expositions than the French, but is infinitely more difficult to translate; and to those who are not thoroughly used to its intricacies it seems to foster, if not to create, confusion of ideas. Germany has now, however, so long included so many publishing centres of scientific importance, and its language has been so generally used by Scandinavian and Sclavonian, as well as by their own naturalists, that a sufficient acquaintance with it, to study the very numerous works it produces, can no longer be dispensed with by the general botanist.

The Dutch language, notwithstanding the number of scientific working naturalists the country has fostered, both at home and in its Malayan colonies, has too limited a range to be generally studied, and is not likely to extend. It is much to be regretted, therefore, that it should have been so much made use of for works intended for the use of others as well as of their own subjects. Some of the late Professor Miquel's most valuable essays (that, for instance, on the vegetation of Sumatra with relation to its physical conditions) remain a sealed book for the botanical community at large. I perceive now, however, that their more important papers in the 'Archives Néerlandaises' and some other journals are being printed in French as well as in Dutch, and we must hope that so commendable a practice may in future be generally adopted.

The Scandinavian nations, Denmark and Sweden, whose men of science have included a large proportion of the most eminent naturalists, have always felt the objections to the publication of the results of their labours in their own language. Linnæus conducted his foreign correspondence and edited all such works as were intended for foreign use in Latin, and his example was much followed. In the first half, however, of the present century, both Danes and Swedes began to indulge more in the use of their native languages, and some important essays, especially on geographical botany and on the cryptogamic section of systematic botany, have appeared in that disguise.

More recently the botanical papers in the Copenhagen Transactions and Journals are frequently accompanied by a French abstract; and in Sweden some of their Natural-History memoirs, such as Morell's 'Monograph of Spiders,' have been printed exclusively in English. German is also a language very generally understood by Swedish men of science, more so amongst some of them than French or English; and it cannot be too strongly recommended to them to bear in mind that, at the present day, the study of Swedish and Danish is not usually treated as more necessary to the general botanist than that of Dutch.

Still less is it the case with the Russian language, which, notwithstanding its poetic beauty, its conciseness, and many other intrinsic advantages, besides the extent of territory over which it is officially spoken, is far too uncongenial with those of Western Europe to give any prospect of its being generally learnt, and the publication in it of any works intended for foreign circulation cannot be too strongly deprecated. The Academy of Sciences of St. Petersburgh and the principal Natural-History Society of Moscow accordingly admit in their Transactions and Bulletins memoirs in French, German, or Latin; but still there are a few important ones issued by these bodies as well as by a second Moscow Society, and others at Kazan and Odessa, entirely in Russian. These are of course ignored by the rest of the botanical world until translated or abstracted in one of the western languages. Such is also the fate of the fortunately very few botanical papers which I have met with in Polish, Bohemian, and Hungarian publications.

The Portuguese and Spaniards, with the vast possessions they formerly held in America, where their languages have persisted as national, and those they still retain (the former in tropical Africa, the latter in the Philippines and West Indies), have in their time done good work in botany, and have generally had the good sense to publish in Latin. There are some floras, however, of their present or former colonies, more used by foreigners than by themselves, which are entirely in their own languages. But these languages, are, I believe, not now spreading further, and in America, at least, English is gaining upon them for business transactions. For the Portuguese language I have little sympathy, for it has always appeared to me harsh and disagreeable; but one cannot but feel some regret that so noble and powerful a language as the Spanish should now be applied to so little purpose.

Italian botanical publications are rather numerous and of some importance, especially in physiological and theoretical botany (their floras are mostly in Latin); the language is also so generally and deservedly admired in a literary point of view, and so far from difficult to those who are acquainted with Latin and French, that some knowledge of it might be recommended to botanists. Yet such general acquaintance with it ought not to be too much relied upon; and Italian botanists will do well in continuing to resort to Latin or French for such works as are intended for the use of foreigners. And, lastly, with regard to modern Greek, we can only hope that its use will be closely restricted to purposes of local instruction, which is indeed the character of the few botanical publications I have seen in that language.

We may now proceed to consider the principal works in systematic botany recently published or now in progress, under the several heads above enumerated.

1. Ordines Plantarum, or General Expositions of the Orders and Suborders constituting the Vegetable Kingdom.

It is to these 'Ordines Plantarum' that we are now obliged to limit our

demands for single general histories of all plants. Alph. de Candolle, in the "Réflexions" above referred to, has shown how hopeless it is to expect the completion of any single 'Species Plantarum,' even if limited to the technical elaboration of the 150,000 or more species and subspecies now known, and a 'Genera Plantarum' has now become a long and tedious labour. But we have a right still to hope that a general account of the Vegetable Kingdom, such as pre-Linnean botanists used to edit, but keeping pace with our advanced knowledge, may still be issued from time to time, in a single volume, as the work of a single author, provided he limit himself to the higher groups, to orders and suborders in number not above a few hundred, neglecting the lower groups, genera, and species, except for illustration or exemplification.

In such a work we should expect, for each order or other group illustrated, the following particulars:—

(1) A diagnosis or short indication of its most important or most generally prevailing character.

(2) A more detailed technical description of its general characters, with indication of known exceptions.

(3) A discussion of its affinities, including an indication of the line of demarcation adopted for its separation from the orders into which it may pass insensibly, as well as of such aberrant or isolated forms as may lie between it and some order otherwise separated by a wide gap.

(4) Its geographical distribution and the modifications of its characters which prevail in different countries.

(5) Its connexion with extinct forms.

(6) Its properties and applied relations, industrial, economical, or pharmaceutical.

Such a general history of plants is so useful not only to all classes of botanists, but to the followers of other branches of natural and other science, that it is most desirable that it should be drawn up in one or more of the most widely diffused modern languages, and accompanied by well-selected explanatory illustrations.

We have two works which have fulfilled the greater number of the above conditions, bringing the science down to the comparatively recent periods when they were first prepared:—Lindley's 'Vegetable Kingdom,' published in 1845, in English, somewhat modified in Endlicher's 'Enchiridion Botanicum' in Latin in 1846, and reissued by the author, with many additional notes, in 1853; and Le Maout and Decaisne's 'Traité de Botanique,' published in French in 1868, translated into English by Mrs. Hooker, with considerable additions and some modifications by Dr. Hooker, in 1873.

Lindley's 'Vegetable Kingdom' was chiefly founded upon a large number of original observations, notes, and other materials he had collected and partly worked up in contemplation of a 'Genera Plantarum,' a work which the increasing calls upon his time and thoughts obliged him in the first place to postpone, and which he finally gave up on the appearance of the first parts of Endlicher's 'Genera.' These materials were elaborated with great care into his 'Natural System of Botany,' 2nd edition, 1836, and afterwards extended, chiefly by compilation, but always under the guidance of his very extensive practical knowledge of plants, into the 'Vegetable Kingdom,' which long remained a most valuable *résumé* of all that was important to know of the 303 orders into which the subject matter was divided. This work, however, is now nearly thirty years (or the greater part of the original matter nearly forty years) old, and is thrown quite out of date by the great progress the science has made during that period. The present proprietors

have, I understand, made proposals for the preparation of a new edition ; but this would scarcely be fair to the memory of the talented author. There are many errors in it which he would have corrected and which must be corrected, there are many views which he would now have modified and which must be modified, but it would be impossible to tell to what extent he would have admitted such corrections and modifications ; and they at any rate would bear so important a part upon the whole plan, that the new editors would not be justified in issuing the altered work under the sanction of his name. It must be in a great measure rewritten, as will clearly appear on consideration of the following particulars :—

The technical characters of each order would be carefully checked in every particular. They were often taken from some one or two genera supposed to be typical, and in some instances have been proved inapplicable even to the great bulk of the order, or to have been founded wholly on error. In many cases they may require considerable extension as to particulars which have proved to be more important than they were originally estimated.

The affinities given require reconsideration throughout. Lindley insisted on the principle, which was at that time generally prevalent amongst the first naturalists, that affinity was no more than correspondence in structure, more or less modified in proportion to its connexion with the phenomena of life, and that an absolute scale of the relative value of characters founded on their degree of constancy could be drawn up, so as to form a practical test of natural affinities ; and it was from an adherence to this rule that, in grouping his orders, he was led to dissociate such natural allies as Apocyneæ and Asclepiadeæ or Ericaceæ and Vaccinieæ in order to class them with others universally acknowledged to be more remote. The new light thrown on the subject by the doctrine that affinity is the result of consanguinity, would, there is very little doubt, have been taken fully advantage of by Lindley himself. He would have acknowledged that there is no character which may not be of very different importance in different orders or genera, or even in different countries in one and the same order or genus, and that the true characters of all natural assemblages are not so extremely simple as he then believed them to be (see 'Veg. Kingd.' Introd. p. xxix). The adoption of this theory would entail the rewriting and extending the important paragraphs introduced by Lindley immediately after the technical characters of each order, and destined to indicate the most generally constant features and the most important aberrant forms exhibited in it, and their connexion, near or distant, with other orders or isolated genera or species.

Geographical distribution has, since Lindley wrote, acquired great importance with reference to natural method, as well as forming now an essential item in the general history of plant-races. Although never neglected in the 'Vegetable Kingdom,' it requires much further development, with a *résumé* of such evidences as the recent progress of the science has collected, respecting the presumed origin and extension of the several orders. And to this should be added a reference to the localities and the presumed geological periods among the remains of which well-authenticated representatives of any order may have been found. This, however, should only extend to the few cases where the evidences are really satisfactory. The numerous palæontological identifications derived from impressions of leaves only, upon which so many expositions of ancient distribution have been founded, are for the most part mere guesses, more likely to lead astray by giving a false support to preconceived theories than to supply any sound data for the history of plant-races.

The properties and applied relations, the "qualitates et usus" of Endlicher's 'Enchiridion,' are very fully exhibited by Lindley, and would only require revising in conformity with the advance of the science of applied botany, much promoted of late by various important works and essays, and in no small degree by the establishment of the Kew Museum.

The sequence of orders adopted in the 'Vegetable Kingdom' is a very objectionable one. The practical convenience of following the Candollean sequence in its main features, until some other one shall have been propounded which shall prove to be such an improvement as to ensure its general adoption, has been too clearly brought forward by Dr. Hooker and others to make it necessary for me to repeat the reasons adduced. Lindley felt its defects, as we all do, but failed in his repeated attempts to remedy them. He was, indeed, so little satisfied with any of the four different systems he successively proposed, that he adopted none of them for his own herbarium, in which he arranged the orders alphabetically. Brongniart's arrangement has found its way into a few French works, and Endlicher's into a few German ones; but the very numerous ones proposed by other French, German, and Swedish systematists have rarely been followed by more than the individual authors, and many of them have only been broached in text-books without ever having been put into practice. The Candollean series is so generally adopted in floras, that these attempts to interfere with its universality have hitherto only produced confusion.

To sum up, it appears to me that the most useful work a competent botanist could now apply himself to would be a new 'Vegetable Kingdom,' founded on that of Lindley, but extended and modified according to the above suggestions.

Le Maout and Decaisne's 'Traité de Botanique' is an excellent and most valuable work, bringing down the science, in most respects, to the year 1868, taking well the place of Lindley's 'Vegetable Kingdom,' and now our standard history of plants. With great original merit it is still further improved by Hooker's notes and additions, including a rearrangement of the 293 orders according to the Candollean sequence; and the illustrations, many of them original, from Decaisne's own drawings, may be thoroughly depended upon for that most essential of all qualities, their correctness. Yet in some respects it seems to require rewriting, which of course could not be done by an editor. Independently of a few oversights and accidental errors, there are some partial views which are more or less out of date, and the general principles followed are essentially pre-Darwinian. How far the French authors may or may not be prepared to adopt the theory of evolution does not appear, it is not in any manner alluded to; but the old doctrine that affinities are to be determined by a calculation of resemblances, estimated according to a fixed scale of the relative value of characters, is as absolutely insisted upon by Decaisne and Le Maout as it was by Lindley, and is to a certain degree practically carried out in this and others of the principal author's excellent systematic works, with the usual result. Some of the groupings of species or genera, which, when tested by the value assigned *à priori* to the characters used, ought to be highly natural, have proved, on the contrary, to be purely artificial. This, however, is not frequently the case with Decaisne; he knows too well how to appreciate natural affinities to follow strictly in practice the rules so stringently inculcated in theory.

I can scarcely include Baillon's 'Histoire des Plantes' amongst methodical 'Ordines Plantarum,' for there is no method in it; it is rather a series of essays or notes on the principal genera of various orders taken at random,

intended, in the first instance, to illustrate Payer's views on organogenesis, and thence enlarged into desultory reviews of the orders, exhibiting in many instances undoubted talent, containing a number of shrewd observations, accompanied by beautiful illustrations, and followed by technical characters of genera, in which but very little is original, being mostly transcripts from our 'Genera Plantarum' and some other works. The result is a work not sufficiently concise, exact, or methodical for scientific reference, too much encumbered with technical matter for general popular use, although it may well adorn a scientific drawing-room table. It was begun in 1867, and four volumes and a half are now completed. These, however, scarcely embrace one sixth of the vegetable kingdom; and if the same plan is followed throughout, the work must ultimately extend to some five and twenty to thirty volumes. An English translation is in progress, two volumes being already published. That Baillon should have undertaken so cumbersome a work, with so little of that clear method for which his countrymen are justly celebrated, is the more to be regretted, as the theory of organogenesis, which it has been his great object to develop, is one of the greatest aids recently introduced into the investigation and determination of natural affinities, wherever it has been critically applied and properly checked by other classes of observations.

2. Genera Plantarum, or Systematic Descriptions of all the Genera constituting the Vegetable Kingdom.

This is the utmost extent to which we can expect to see all known plants methodized and described within the limits of a single work by a single author; and even in that work they can only be treated of scientifically and technically for the use of the botanist, without the generalities and accessory details which adapt the 'Ordines Plantarum' to a wider circulation. Taking for genera those groups of species, those plant-races of an intermediate grade between the order and the species, which appear to be the best defined in the present state of nature, and to which the generic nomenclature can be applied with the greatest practical advantage, we should estimate them as rather above eight thousand for Phenogams and vascular Cryptogams, and at least a thousand more for cellular Cryptogams. Such a work can still be brought within the compass of about three manageable volumes. Indispensable as it always is for the working botanist, the demand for it would never be sufficient to admit of its being simultaneously issued in the three generally diffused modern languages, and it therefore usually has been, and will still be, most usefully drawn up in botanical Latin.

Since the introduction of the natural method, there have been but two good complete 'Genera Plantarum,' the original one of Jussieu in 1789 and that of Endlicher, with its supplements ranging over the five years from 1836 to 1840; the latter was the work of a clear methodical head, applied with great care and assiduity to a stock of materials very fair for the time, and the general plan is good. But it was necessarily in a great measure a compilation, and it affords no means of judging how far the characters given had been confirmed by actual observation. This would have been the more useful, as it is evident that in many cases ordinal characters are repeated under each genus upon no other authority than that the genus had been referred by its proposer to the order in question. The work had, moreover, become quite out of date; and the need of a new one was so much felt, that Dr. Hooker and myself undertook the preparation of a 'Genera Plantarum' on a plan which long experience had led us to hope might be an improved

one. The first part was published in 1862, and the whole of the first volume (completing the Polypetalous Dicotyledons) was, with the aid of a supplement, brought down to the year 1867. The first half of the second volume, issued last year, contains nearly half the Gamopetalous Dicotyledons, the remainder of which, completing the second volume, will, we hope, be in the printer's hands early next winter. Monochlamydous Dicotyledons and Monocotyledons will probably fill a third volume.

The plan which we have set to ourselves has been to prefix to each volume a methodical diagnosis or short conspectus of the most striking characters of the several orders contained in the volume, and under each order to give the following particulars:—

(1) The general characters of the order.

(2) A short sketch of its geographical distribution.

(3) An equally abridged sketch of its affinities.

(4) An enumeration of the aberrant forms observed in individual genera, an addition which is, I believe, here introduced for the first time, we having both of us long felt the want of it in general works.

(5) A conspectus of the genera—that is, a short and as much as possible contracted exposition of the most salient characters of each genus, as a guide to the determination of plants. Where the order is large enough, or heteromorphous enough, to be subdivided into distinct suborders or tribes, the tribual characters are given in this conspectus; and where the tribes are numerous, as in Leguminosæ, Umbelliferæ, Rubiaceæ, and Compositæ, a short conspectus of them precedes that of the genera. This arrangement into tribes has been everywhere thoroughly investigated, and in the case of most of the large orders entirely recast.

(6) An enumeration of genera which are either so nearly allied that they might be supposed to belong to the order, or which have been erroneously included in it, or have been so imperfectly described as to be wholly doubtful.

(7) Then follow the detailed characters of each genus, with an evaluation of its extent, its geographical distribution, a full synonymy, references to plates illustrating it, and such occasional notes as appeared necessary on affinities, on genera confounded with it, or in our opinion unadvisedly separated from it. Where the genera are sufficiently large or varied, the characters of its primary sections are entered into.

We have taken care to indicate the genera, very few in number, of which we have been unable to examine any specimen, and the characters which we have not personally investigated, indicating always the sources whence those we give have been taken; and we have also thought it necessary to pay particular attention to the typographical details of the work, an element of clearness which is sadly neglected in many German and some French systematic works.

3. Species Plantarum, or Systematic Enumeration and Descriptions of all known species.

In the above-quoted article in the 'Natural-History Review' for October 1864, I gave a sketch of the last attempts made to publish a complete 'Species Plantarum,' including a detailed history of the great work of modern days, De Candolle's 'Prodromus,' which I need not now repeat. This work has now been brought to a conclusion by the issue, last autumn, of the seventeenth volume, forty-nine years after the publication of the first. Its celebrated originator began in 1818 a 'Systema Vegetabilium,' with all the details of the so-called new editions of Linnæus, but drawn up and arranged

according to the principles of the natural method. After the issue of the second volume in 1821, he found himself obliged to give up the task as already far beyond the means of a single life, and substituted an abridged 'Prodromus,' which he long continued, almost unassisted, at first with a vague idea of its being preliminary to a more detailed work. As that hope was finally extinguished, and especially since the elder De Candolle's death, the 'Prodromus' has been gradually extended into a series of concise monographs by different authors, differing much in merit, but drawn up as nearly as could be according to one plan, and uniformly printed in the successive volumes of a single work—the younger De Candolle, besides working up many of the orders himself, having gone through the tedious labour of editing them, giving to the botanical world a splendid monument of industry and perseverance, which will long be of great practical utility. It is now nominally complete, but only as to Dicotyledons, and the first volumes are quite out of date. They are, however, to a certain degree, supplemented by Walpers's 'Repertorium' and 'Annales;' and the botanist has thus, in thirty volumes, a very fair repertory of all described Dicotyledons up to a recent date. For Monocotyledons he has only Kunth's 'Enumeratio,' which extends to little more than half the class, having been put an end to by the author's death in 1850. For the remaining portion of Monocotyledons, for Cryptogams, and for all recently discovered species or recent methodizations of old ones, he must have recourse to detached monographs and floras, which are henceforth likely to be his only resource for the history of species. Alphonse de Candolle, in the above-quoted "Réflexions," has shown how little chance there is of a uniform 'Species Plantarum' being again undertaken with any prospect of its being brought to a successful conclusion. He calculates that it would require fifteen or sixteen years' labour of some five-and-twenty botanists, working under the direction of about eight to ten editors, a combination which it is highly improbable will ever be practically brought to bear. His calculations may, however, be a little overcharged. He supposes that each botanist would not work up more than 300 species in a year; that may be the case in a monograph when every detail is to be gone through from personal observation, but this would not now be necessary in a general 'Species Plantarum,' which would be most useful as a concise methodical compilation. Much of the labour expended on the 'Prodromus' and on detached monographs and floras need not be repeated. As pre-Linnean synonyms, upon which so much time was formerly expended, have now been generally given up, so, for post-Linnean synonyms, there would now be no use in repeating those given in the 'Prodromus' and other works compiled from, unless where errors have been detected; and this alone would save a great deal of time, labour, and expense. And with regard to the greater number of the orders or genera contained in the recent volumes of the 'Prodromus' and the best modern monographs and floras, a careful and intelligent abridgment of the specific characters without reexamination is all that would be necessary.

It might be useful to consider what would be the requisites of any such abridged 'Species Plantarum' or 'Synopsis,' restricted within limits which should render it possible, at least as to phenogamous plants.

We might expect it to follow the sequence of orders the most generally adopted, that of the 'Prodromus' and of our 'Genera Plantarum,' with such slight modifications only as the progress of science has rendered necessary, without attempting hypothetical improvements.

To each order and to each genus should be given short diagnostic cha-

racters, abridged from the last 'Genera Plantarum' or other best sources, selecting chiefly those which are most essential and contrasted, but including also the most striking or the most general amongst the adaptive ones, and a general indication of geographical range, with careful reference to the works where more details are to be found.

Where the orders or genera are large, a synopsis or conspectus of the principal divisions and subdivisions would be useful.

To each species should be given :—

(1) The name.

(2) The diagnosis, specific character, or abridged description, which are but different names for the same thing, and which it appears to me would be always more satisfactory in the nominative than in the ablative case. After the example of Linnæus, and based upon the doctrine of the fixity of species, it has been almost universally the custom to distinguish the specific diagnosis and description, the former to contain the absolutely distinctive characters (any deviation from which would exclude a plant from the species), the latter to aid the student in identifying a plant by the enumeration of characters which, though general, might vary in the same species, or which it may possess in common with other species. In order to mark the more strongly this difference, the diagnosis, when in Latin, has been given in the form of the ablative absolute, the description in the ordinary nominative form. There is, however, nothing really absolute in nature. There is no class of characters which may not occasionally admit of exceptions; and although care should be taken to select the most important and constant ones, yet, in some instances, those which are generally discarded as too variable for a diagnosis, such as dimensions, colour, &c., may yet be most useful, or even essential, for the distinction of species or even of genera. These diagnoses, moreover, to be useful should be short. We cannot now restrict them to the twelve-word law of Linnæus, but a twelve-line ablative diagnosis is an absolute nuisance.

(3) Reference to the source whence the diagnosis is taken, to the work where a further description, the synonymy, and history of the species are to be found, and to any plates where it may be satisfactorily represented; and all further synonymy should be avoided, except where it may be necessary to refer to descriptions, names, or modifications published since the one specially abstracted from.

(4) The habitat of the species.

(5) Occasional notes on affinities or other points in the history of the species should be very sparingly indulged in, and only when they may assist essentially in the provisional determination and elucidation of a plant. All discussions on doubtful points and all details should be reserved for monographs or separate papers, where alone they can really tend to the advancement of the science.

Each volume of the 'Synopsis' would of course be accompanied by a full index of genera, species, and such synonyms as it may have been found necessary to give.

The whole work would be so indispensable to botanists of all nations, that, like the 'Genera Plantarum,' it should be entirely in botanical Latin, which, moreover, from the number of conventional expressions to which a technical meaning has been assigned, is specially suited for short diagnoses.

No new species should be first published in this 'Synopsis.' Nothing has tended more to produce confusion in systematic botany than the publication of real or supposed new species, with short diagnoses, unattended by any full

description or detailed indications of its affinities, &c. However carefully the diagnosis may be worded so as to distinguish the species from those previously published, it would be insufficient for its identification, and full descriptions would be inadmissible from the plan of the work. At the same time it is to be expected that the author, in preparing the 'Synopsis,' should meet with new forms, which he may be desirous to make known, in order to render his work as complete as possible. But his course should be to give their full history in a separate monograph, to which, *when published*, he could refer in the 'Synopsis.' He should here not only thus avoid all addition to the numerous puzzles with which the science is overloaded from insufficient description, but strictly abstain from all mention of manuscript and other names which, according to the recognized rules of nomenclature, are not admitted as sufficiently published.

The grade of plant-race to which the specific name and diagnosis should be attached, would be the species in the Linnean sense, which, though not susceptible of a strict definition, is pretty generally understood amongst botanists, whether they may designate it as a true species, a Linnean, or a compound species. The 'Synopsis' might also distinguish marked varieties whose admission or rejection as species might be doubtful; but the innumerable forms variously termed varieties, subspecies, or critical species should be passed over in silence, as their admission would simply render a general work impossible, and a more partial one comparatively useless. The enumeration and distinction of the various forms of *Brassica campestris* and *oleracea*, of *Pisum sativum*, *Viola tricolor*, &c. may be serviceable to the agriculturist or gardener, that of the forms of *Rubus fruticosus* may be interesting to the investigator of the flora of a limited district, but they are only useless encumbrances to the general systematist as well as to the naturalist in other branches who would have to make use of the 'Synopsis;' and the names and diagnoses of two hundred forms of *Draba verna* would be a simple nuisance, of no use whatever to any one*.

Taking the species, therefore, in the Linnean sense, we should, with Alph. de Candolle, estimate the number of Phenogams now published, or in the course

* The mode of dealing with species which in the present state of vegetation pass into each other through a series of intermediate forms which cannot fairly be supposed to be hybrids, is well discussed by Nägeli in a series of papers in the 'Sitzungsberichte' of the Munich Academy for 1866, the result of careful observation chiefly of the genus *Hieracium*. After admitting himself to have been originally a firm believer in the fixity of species and a strong advocate of the hybrid parentage of the large number of intermediate forms observed, he acknowledges his conversion to the doctrine of evolution. "In the present state of the science" he sees "no other possibility than the assumption that the species of *Hieracium* have arisen by transmutation either from extinct or from still surviving forms, and that there are still persistent a great number of the intermediate stages (races) formed either by the original differentiation of the extinct species, or in the course of the transformation of one yet living species into the diverging forms."—*Sitzungsber.* 1866, i. 330.

In a subsequent paper he shows that the genus *Hieracium* affords instances of great diversity in the degree to which differentiation has attained and in the definiteness of the species established by the extinction of intermediates. He instances, amongst those to which he would in their present state assign the rank of species:—

1. Aggregate forms, such as *H. pilosella*, which cannot as yet be separated into distinct groups. *H. Hoppeanum*, Schult., *H. Pelleterianum*, Mérat, *H. pseudopilosella*, Jen., are not yet sufficiently isolated by the disappearance of intermediate forms to be ranked as species.

2. Forms which, by the disappearance of closely allied ones, have attained sharper and more fixed limits, and yet between which isolated intermediates may still be found, are exemplified by *H. auricula*, *H. aurantiacum*, and *H. pilosella*, or by *H. murorum*, *H. villosum*, and *H. glaucum*. On the other hand, it is uncertain whether the relations of

of publication; from materials already in our herbaria, at between 110,000 and 120,000. A competent botanist would readily get through three or four thousand in a year. In the 'Flora Australiensis' I had no difficulty in preparing a thousand to twelve hundred in the year, and that was all original work, entailing the personal examination of every species often in numerous specimens, and a long and tedious investigation of synonyms. Such a compilation as I have above characterized would require, it is true, a competent knowledge of plants and occasional verifications; but still the labour would be reduced by at least two thirds; and 300 species a month, with a month or six weeks' vacation, would be no great strain upon the mind. Thus three or four botanists might complete the synopsis of ten thousand species in the year; and the general synoptical enumeration of all known Phenogams would not be beyond the range of possibility, however little chance there may be of my living to see it commenced.

Cryptogamic details require the cooperation of more special botanists, who have already furnished us with monographs or synopses of some of the primary groups. In Ferns, Hooker's 'Species Filicum' is very complete, and is brought down to the present day by his 'Synopsis Filicum,' edited by Baker, of which a new edition is now ready. For Mosses, the last general work is Carl Mueller's 'Species Muscorum,' completed in 1851, since which date the number of species described has been at least doubled. Modern muscologists have, however, so much lowered their generic and specific standards, that they have placed the study of this most interesting class of plants almost beyond the reach of the general botanist. A monographer who would boldly reestablish the species according to Linnean principles, and group them in a manageable number of genera, treating the lower grades as subspecies only, disencumbering the binomial nomenclature from them, would render a great service to science. In Hepaticæ there has been no general 'Species' since that of Gottsche and Lindenberg, begun in 1844, and, by means of supplements, brought down to 1847. Lichens are still more in arrear. Nylander began, indeed, a new 'Synopsis' in 1867, but it has never been continued. In Algæ, Agardh's 'Species Algarum,' commenced in 1848, was completed in 1863; and Kützing's 'Phycologia' and 'Species Algarum,' issued in 1849, have, through the nineteen volumes of his 'Tabulæ,' been brought down to 1869. The enormous class of Fungi is much more complicated, and their study much more specialized than any other branch of systematic botany; and although mycologists, no more than phenogamists, have at present any general comprehensive systematic work, they have the advantage of Streinz's 'Nomenclator,' a convenient general index to the numerous detached monographs and papers descriptive of fungi.

4. MONOGRAPHS of Orders and Genera.

Monographs, like 'Ordines Plantarum,' are general histories of plants; but the field being limited to single orders or genera, the author can descend to

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H. auricula and *H. glaciale*, or of *H. murorum* and *H. vulgatum*, should be included in this stage, or are still in the first-mentioned category.

3. Species between which no constant intermediates survive, but which still are capable of producing intermediate hybrids, are represented by *H. alpinum* and *H. villosum*, by *H. alpinum* and *H. glaucum*, by *H. murorum* and *H. umbellatum*, &c.

4. Lastly, the three sections *Pilosella*, *Archieracium*, and *Stenotheca* are races which have become so far distanced from each other that hybrid fertilization no longer takes place between them.—*Sitzungsb.* 1866, i. 472.

species and primary varieties instead of limiting himself to orders and tribes. They are at the present day amongst the most important botanical works. They are required by the systematist for the identification of plants, and by the general naturalist as the source whence he is to derive the data he requires respecting individual species in theoretical, geographical, physiological, or applied botany. This preparation has been recognized as the best exercise for the young botanist; and monographs of difficult orders have been received as most valuable contributions from some of the most eminent heads of the science.

Our requirements for a complete monograph are analogous to those we expect in 'Ordines' and 'Genera Plantarum,'—methodical arrangement, technical diagnoses and descriptions, indications of geographical distribution, "qualitates et usus," and occasional notes on affinities and systematic limits, including an investigation of synonyms, well selected illustrations adding always to the practical value. The technical diagnoses and descriptions for the use of the systematist ought invariably to be drawn up in botanical Latin; the more general matter would usually be more readily written, and often much more intelligible, in one of the three general modern languages.

This similarity required in the histories of orders, genera, and species has not, however, been hitherto generally acknowledged, and could not even have been admitted so long as it was believed that there was an essential difference between the groups—between the definite fixity of species and the more arbitrary limitation of genera and orders. In early systematic works, therefore, whilst the definitions of orders and genera were single and in ordinary phraseology, it was thought necessary, in the case of species, to give a double definition—a diagnosis containing the supposed fixed characters, by which the species could be absolutely tested, and therefore expressed in the ablative absolute, and a description admitting all classes of characters in the ordinary form of phraseology. As the number of species increased, greater extension was habitually given to both diagnosis and description, till they became unwieldy for use, without some short indication of the most striking points to be attended to. This has been done in two ways, either by prefixing to the group of species described a tabular clavis or a short conspectus of the contrasted characters to which attention is specially called, or by italicizing them in the long diagnosis. The former course entails often the useless repetition of the same characters three times over, in the clavis, in the diagnosis, and in the description; the latter, seeing that the italicized words are usually adjectives, often occasions confusion and loss of time in searching for the substantives to which they belong. Now that it is laid down that there is no more absolute fixity in a species than in an order or genus, the complication is no longer necessary; there is no more need of an absolute test in the one case than in the others. In all we want a short indication of the most prominent contrasted characters for approximate or preliminary determination, prefixed to the detailed description for subsequent verification.

These short characters are given in three different forms:—1st, a tabular clavis, more or less on the dichotomous principle, as is now frequently exemplified in local floras; 2ndly, a conspectus prefixed to the whole group of species; 3rdly, the short character prefixed to each description. In elaborate monographs, where the descriptions are long, the conspectus is probably the most satisfactory form; in more concise ones, where the descriptions are short, the tabular clavis will be found more useful. In synopses, where the descriptions are reduced to occasional notes or limited to new

species, the short characters or diagnosis (which, I think, should never be omitted) would form the body of the work, and the notes and descriptions, when they occur, should be given under each diagnosis.

It should always be borne in mind by the monographist that the great test of the quality of a descriptive work lies in short descriptions, diagnosis, and conspectus or clavis. Any tyro with a little practice can draw up long descriptions of *specimens*, fairly detailing every organ; but the selecting the characters necessary to give a good idea of a *species* in a short description requires a thorough knowledge of the subject and a methodical mind. Still more difficult is it to prepare a good clavis. After half a century of experience in using as well as in making these keys, I find that I have failed in some of those on which I had spent the greatest pains; and in some floras I have met with tabular keys which are in many respects rather impediments than aids to the determination of plants. At the same time a successful clavis or contrasted conspectus is an excellent test of the quality of a method—of the appropriate grouping into genera, sections, and species.

Really good monographs are not very numerous, and several of them not very recent. Some of the best among complete monographs have proceeded from the French school; and I may refer as models to Richard's Coniferæ, Adrien de Jussieu's Malpighiaceæ, Decaisne's Mistletoe and Lardizabaleæ, Weddel's Urticeæ, Tulasne's Monimiaceæ, and others. Their illustrations also, as well as some of the German ones, far exceed our own in neatness, clearness, and correctness of analytical detail. For more concise and technical monographs some of the recent volumes of the 'Prodromus' afford good examples. Amongst the worst I have had occasion to refer to are De Vriese's detailed monograph of Goodenovieæ and Steudel's more concise synopsis of Glumaceæ. The Germans have of late years done but little in this respect beyond what has been incidental to the 'Flora Brasiliensis.' In England the principal recent ones have been Hiern's Ebenaceæ, remarkable for the scrupulous care with which the minutest details have been worked out, and Miers's Menispermaceæ, the value of which we fully recognize, although we do not accept the low grades to which he assigns the rank of genera and species respectively. Some good partial ones have appeared in the Swedish and Danish as well as our own Transactions; and we have had excellent Russian and North-American monographic memoirs, limited, however, to plants of their own territories, and therefore scarcely coming under the present head.

The orders now most in need of the labours of able and methodical monographists are, in the first place, the Monocotyledonous ones. The largest of them, that of the Orchideæ, was once well worked up by Lindley; but the enormous additions made to it since these curiously diversified plants have been brought into fashion by horticulturists have thrown the 'Genera et Species Orchidearum' quite out of date. The next two in point of number, Gramineæ and Cyperaceæ, have been undertaken chiefly by Germans; and if Trinius, Kunth, and Nees von Esenbeck had partially cleared up the confusion which prevailed among them, Steudel has in a great measure contributed to throw them into a worse chaos than before. Munro, who has long made the Gramineæ a subject of special study, has as yet only published his monograph of Bambuseæ. In Cyperaceæ, Böckeler's desultory descriptions of those of the Berlin Herbarium are sometimes perhaps rather obstacles than aids to a general systematic acquaintance with the order. Masters's monograph of Restiaceæ is limited to the African species. Klatt's Irideæ do not very well bear the test of practical use. Martius's splendid work on Palms requires already much supplementing. Baker is now rendering good service in working

up the Liliaceous groups; but some of the remaining orders appear to have been almost entirely neglected.

Among Dicotyledons the orders which I would particularly recommend as the subject of specific monographs are those which are contained in the first volume of the 'Prodromus,' and more especially such as comprise a large number of plants from the temperate and mountain-regions of the northern hemisphere (*e. g.* Ranunculaceæ, Cruciferæ, many genera of Papilionaceæ, Rosaceæ, &c.); and this not only for the purpose of methodizing the data supplied by the numerous writers on local floras, but with a view to the careful and intelligent, but merciless excision of the overwhelming numbers of races of lower grades which have, to the great detriment of science, been allowed to rank with those legitimately deserving the name of species. Tropical and southern orders are so much within the scope of the great floras now in course of publication, that special monographs, except as connected with those works, are not in such immediate demand.

Monographs of variable or ill-defined *species* have also their importance, if worked out with a view to ascertaining the extent to which, and the circumstances under which, a species varies or is connected with others, and not for the sole purpose of dividing and subdividing it into races of a lower grade, to receive the same binomial nomenclature as the normal or compound species. Such a monograph should comprise the history of the species throughout the area it occupies, the investigation of the modifications which its several organs undergo in different localities, of the extent to which the divergencies are carried out under different circumstances, of the relative numbers (that is, of the frequency or rarity) of the divergent forms, of the extraneous circumstances (such, for instance, as the vicinity of allied species &c.) which may be supposed to have influenced these divergencies—every thing, in short, which might tend to show whether the variability is an indication of a progressive differentiation of a flourishing race, or a temporary result of hybrid fertilization, or the immediate effect of climatological or other conditions affecting the individual rather than the race. The working out such a monograph in some one or two species would be highly instructive to the general botanist, and the data obtained might consolidate the foundations of more general speculations. It may even be useful to define and to give subordinate names to those varieties which approach the state of distinctness which might entitle them to rank as species; but the technical defining of the slight diversities of form assumed by a species in a limited locality, however constant those varieties may there be found, can be of little interest but to the inhabitants of that locality, and the giving them names as of species to be received by general botanists is only adding to the encumbrances with which the science is overloaded, without a single corresponding advantage.

5. Floras, or Histories of the Plants of particular countries or districts.

Floras, like monographs, are histories of plants so limited that the author can descend to species; but the limit is geographical instead of systematic. The general requirements as to their contents are the same as in respect of Ordines Plantarum and Monographs, but with greater variety in the details, according to the class of persons for whose use they are intended. If the country of which the flora is given is large and the civilized inhabitants comparatively few, the work is chiefly useful to the general botanist, and requires special attention to the technically systematic portion in botanical Latin. Where the geographical extent is more limited, or the science generally cultivated amongst its inhabitants, the general description and history should be

more extended, and the local language may be admitted or preferred according to circumstances. The more botany is cultivated in a country, the more variety may be given to its floras—a scientifically morphological one for a text-book in classes, an easy descriptive one for the beginner and amateur, a very fully detailed one for study at home, an abridged synopsis for a companion in the field. In all, correctness and clearness of method and language are the first qualities requisite; and wherever any instruction or information beyond the means of determining plants is the object, geographical distribution (without as well as within the special area of the flora) is a most essential point to be attended to. It is to local floras that the general botanist must have recourse for most of the data he requires for the investigation of the history and development of plant-races; and his reliance upon the correctness of the facts supplied depends much upon the intrinsic evidence of a careful comparison on the part of the author of his plants with those of countries adjoining to or otherwise connected with his own. It tends also very much to enlarge the ideas of a local botanist to learn how very widely spread are species which he has been accustomed tacitly or expressly to consider rare local creations, and how very differently plants may be distributed or varied in other countries from what he has observed at home. Exotic distribution is, however, a point very little attended to in many of our best modern floras. I well recollect the interest that it gave to the first in which I met with it, Cambessedes's enumeration of the plants of the Balearic Islands, published in 1827; but his example was but rarely followed. More recently, I believe, I was the first to introduce it into British floras. Dr. Hooker has paid particular attention to it in all his systematic works; it is one of the conditions introduced by the late Sir William Hooker in his plans for the series of Colonial Floras, and has been partially attended to by some of the contributors to the great work on Brazilian plants. We may hope, therefore, to see it gradually included in the standard continental floras, as well as in more local ones. It is gratifying to observe that in that of Dorsetshire, just published by Mr. Mansel-Pleydell, special indications are given of the species which extend to the opposite coast of Normandy.

In several of my Linnean Addresses, especially in those of 1866 and 1871, as well as in two articles in the 'Natural-History Review' (one on Maximowitz's "Amur Flora" in April 1861, the other on "South-European Floras" in July 1864) I had occasion to enter into many details relating to the Floras recently published or in progress, which it would be superfluous now to repeat. I may only state generally that those of the central and northern States of Europe are well kept up. Lange and Willkomm's Prodromus of Spanish Plants has very recently made a step in advance by the issue of the first part of the third and last volume, which it may be hoped will be now soon complete. Parlatore's Italian Flora gives no such promise, though it still drags its long pages slowly on. The vegetation of the eastern portion of the vast Russian empire is being thoroughly and scientifically investigated by Maximowitz. Boissier's much-wanted 'Flora Orientalis' has reached the end of Polypetalæ in its second volume, and a third is said to be far advanced. The still more important 'Flora Indica' is at length fairly afloat; two parts, by various authors, under the enlightened editorship of Dr. Hooker, are on sale, and a third is nearly ready. The 'Flora Australiensis' reached its sixth volume last summer; and if health and strength be spared me, I hope to complete the seventh and last next summer. Weddell is, I understand, preparing the third and last volume of his 'Chloris Andina;' and that splendid monument to systematic botany, the great 'Flora

Brasiliensis,' thanks to the munificent patronage of the Emperor and his Government, and to the unwearied zeal and energy of the present able editor, Dr. Eichler, has so far advanced, that its completion, once thought hopeless, may now be fairly reckoned on at no distant period.

Turning to the desiderata in this branch of systematic botany, besides the completion of the above-mentioned works in progress, and of the remaining colonial floras begun or contemplated according to the plans of Sir W. Hooker, there are three which are much in need of a thorough investigation and re-working up on sound scientific as well as practically useful principles. These are the European, the Russian, and the North-American. The three together comprise the whole vegetation of the temperate and cold zones of the northern hemisphere, by far the most extended continuous flora of the globe, and the most closely connected with what we know of the vegetation of the latest preceding geological periods. Its present continuity, with only a gradual east-and-west change in the northern portion, but more and more marked divergencies as it recedes from the arctic regions, and the evidences we have of that continuity having been as great at a former period and in some instances perhaps yet wider extended, would suggest that it ought to be treated as one whole. That would, however, be too great an undertaking for a single hand; and there are other advantages in dividing it into three separate floras, provided the three are carried out according to one plan, with a uniform estimate of specific and generic grades, and each one always in close connexion with the other two. The different materials which each of the three investigators would have to work upon would require some differences in their treatment, besides that each one ought to be an inhabitant of the region he investigates, so as to have some personal experience of its living flora.

The writer of the European flora would be much more bewildered by a superabundance of data than at a loss on account of any deficiency. His first great difficulty would arise from the enormous number of names published by local botanists, and the consequent call upon him to carry out on a large scale that judicious excision of insufficiently differentiated species which I have above urged in the case of monographs. His work would be more in the hands of the general than of the local botanist, and conciseness, method, and accuracy would be more important than minuteness of detail. Innovation would be avoided unless upon very strong grounds. The most useful sequence to be adopted in the present state of the science would be, without doubt, the Candollean, the genera and species restricted to the higher grades sanctioned by the best modern monographists and other systematists. In the majority of cases he would have little difficulty in this respect; and when he comes to such involved genera as *Ranunculus*, *Hieracium*, *Rubus*, &c., where there are really so many indefinite species, he would limit his specific names and descriptions to the 'Hauptformen' of Nägeli, which one set of botanists may designate as Linnean or legitimate and another as compound species. Isolated intermediate forms, whether hybrid and evanescent or more or less constant, and a few of the principal subspecies, varieties, critical or, in the Jordanian view, true species, may require mention by name, with a few descriptive notes where the low grade may be doubtful; but the great majority may be dismissed with a general statement of their having been proposed by dozens or by hundreds, as the case may be, with a careful indication, however, in so far as possible, of the degree in which the species admitted have been observed to vary, and of any difference in this respect in different parts of the area of the flora. The language of such a European flora should be,

without doubt, botanical Latin for the technical descriptions; French or English might be better suited for the occasional notes and geographical distribution.

This geographical distribution would be a most essential feature in the general flora of Europe, which exemplifies the gradual extinction southwards of the arctic plants, and eastwards of a very interesting western flora, whilst a certain number of Asiatic plants enter its eastern limits, but fail to reach the western States; and much interest attaches to the botanical connexion of the Pyrenean and Alpine floras with the north and with each other. Accurate data are much wanted for the inquiry into the history of the dispersion of plant-races, their origin, progress, decline, and final extinction; and to supply these data all general floras will be expected to record for each species the area it occupies within the flora, distinguishing the localities where it is most common and the direction in which it becomes rare, and its ultimate limits if within those of the flora, or if not, noting generally its extension into adjoining regions in identical or representative forms. For the European flora the limits are well marked on three sides:—To the westward, the Atlantic opposes an insurmountable obstacle to any gradual extension of European plants, except in the extreme north. To the south, the Mediterranean and Black Seas and the ridge of the Caucasus give a good natural boundary; for though many of the European forms are still prevalent on the African coasts and in Asia Minor, yet they are very soon arrested southwards by climatological conditions. To the north, the limits of the European flora are those of all vegetation. To the east only is there no definite limit, and an arbitrary line must be drawn to separate it from the North-Asiatic region; that of the Ural, though no better marked botanically than physically, is on the whole the most convenient.

For the Russian, or rather the North-Asiatic, flora (for it ought to include or to be drawn up in close connexion with that of Japan) a methodical and geographical work, by one who should have the intimate acquaintance with the vegetation and the sound views of Maximowitz, would be a great boon. Here, again, the northern limits are those of all vegetation, and the southern ones at present fairly defined by the comparatively unexplored mountain-masses of Central Asia, beyond which the northern plants are replaced by a totally different vegetation; but besides the actual continuity with the European flora to the westward, there is a close connexion with that of North America to the east, notwithstanding the definite limits interposed by the Pacific—a connexion which has been already exhibited by Asa Gray from an American point of view, and by Maximowitz on the part of East Russia and Japan, but still requires a much fuller development. Ledebour's 'Flora Rossica' would form a very good basis for the new work: it is the best complete flora of so large a tract of country which we possess; but it now requires a thorough revision, with the insertion of the numerous additions made by recent explorations, and the geographical data must be entirely remodelled and extended to meet the above-mentioned requirements. With regard to the Japanese flora, abundant materials have been collected and published in various works, chiefly by Dutch botanists; but the absence of all method in Miquel's 'Prolusiones,' where they profess to be enumerated, renders that work of little use to the general botanist, and a geographical flora is very much needed. The connexion, indeed, between Asia and America cannot be studied without constant reference to Japan.

For the North-American flora we must look to Asa Gray. The Americans have for many years past been most active in the exploration of their vast

territory, and its botany has been partially worked up monographically by A. Gray, geographically by Sereno Watson, Porter, and others; but the great mass of data collected are scattered over so great a variety of publications as to render them almost useless to the general botanist. We cannot even approximately fix upon the boundary-line to separate the North-American from the very different Mexican flora to the south-west. Northward it should, if it is wished to make it really instructive, extend, like the two other great floras, to the limits of vegetation; eastward and westward the Atlantic and Pacific afford definite boundaries. But the comparative degree in which the external connexion with Europe and Asia is broken off by the two oceans, the causes of the difference observed, as further illustrated by recent palæontological discoveries, the effect of the north-and-south ridge of mountains and other causes in separating eastern and western races within the territory, and many other important elements in the history of plants can only be satisfactorily investigated with the aid of such a comprehensive, methodical, and geographical flora as we are in hopes the distinguished Harvard-University botanist is now preparing.

6. Specific Descriptions, detached or miscellaneous.

Had I to report only on the progress, and not on the present state also, of systematic botany, I should here stop, for the great majority of recent detached and miscellaneous descriptions are almost as much impediments as aids to the progress of the science. I have too often in my Linnean Addresses, especially in those of 1862 and 1871, animadverted on the mischief they produce to enter now into any details; I can only lament that the practice continues, and is even rendered necessary by considerations not wholly scientific. Horticulturists must have names for their new importations. It is due to travellers who, under great perils and fatigues, have contributed largely to supplying us with specimens of the vegetation of distant regions that the results of their labour should be speedily made known; it is even important to science that any new form influencing materially methodical arrangements should be published as soon as ascertained. But all this is very different from the barren diagnoses of garden-catalogues, and the long uncontrasted descriptions hastily got up for the futile purpose of securing priority of name. I own that I have myself erred in the want of sufficient consideration in the publication of some of the species of 'Plantæ Hartwegianæ;' and some descriptive miscellanea, even by men who stand very high in the science (such as Miquel's 'Prolusiones,' above referred to, and Baron von Mueller's 'Fragmenta'), are rendered comparatively useless from their utter want of method. Whilst, therefore, discouraging as much as possible all such detached publications of new species, I would admit their occasional necessity, but suggest the following rules as the result of a long practical experience:—

No detached description of a new species should be ventured upon unless the author has ample means of reviewing the group it belongs to; and if any doubts remain of its substantive validity, he should refrain from giving it a name till those doubts are cleared up.

The description, when given, should be full, but contrasted, and accompanied by a discussion of affinities with previously known species, and an indication of the place the new one should occupy in the several monographs and floras in which it would be included.

An illustration of the new plant, with analytical details, should never be neglected where circumstances admit of it.

In conclusion, if I am correct in the views I have taken of the desiderata

under the six heads above detailed, I hope it may be admitted that, notwithstanding recent progress, there is still a wide field open for the researches of the systematic botanist, and that his branch of the science is not the mere child's play or herbarium amusement it has been charged with; for no thorough knowledge of plants can be satisfactorily obtained or successfully communicated without scientific method, and no such method can be framed without a thorough study of the plants methodized in every point of view.

Report of the Committee, consisting of Dr. Pye-Smith, Dr. Brunton (Secretary), *and* Mr. West, *appointed for the purpose of investigating the Nature of Intestinal Secretion.*

For some time the opinion has prevailed among physiologists that the nervous system not only exerts an influence upon the calibre of the vessels supplying glands with blood for secretion, but that the secreting cells themselves are excited to action by nervous stimuli. So firmly, indeed, has this opinion been held, that Pflüger's discovery of nerves terminating in the secreting cells has been almost universally accepted, notwithstanding his failure to demonstrate these structures to others. Partly, no doubt, this belief has been due to the high personal consideration in which this distinguished physiologist is justly held, but it is also due in part to the conviction which prevails that such structures must exist.

A distinct proof to this effect has been afforded by the researches of Heidenhain, on the effect of atropia upon the secretion of the submaxillary gland.

When one of the nerves going to this gland (viz. the chorda tympani) is stimulated, two effects usually follow:—First, the vessels going to the gland dilate, the blood flows quickly through them, and a free supply of lymph is poured out into the lymph-spaces surrounding the gland; secondly, the cells of the gland absorb this lymph, convert it into saliva, and pour it out into the duct of the gland.

If the animal be partially poisoned with belladonna (or its active principle atropia), or if atropia be injected into the vessels of the gland itself so as to exert its poisonous action upon the branches of the chorda tympani ending in the gland, a very different result takes place.

When the nerve is then irritated the vessels dilate as before, the blood pours rapidly through them, but not a drop of saliva is secreted. That part of the chorda tympani which acts on the vessels has not been affected by the poison, but those fibres which go to the secreting cells and stimulate them to secrete have been paralyzed by it.

It is obvious, however, that the salivary secretion is only exceptionally induced by direct irritation of the chorda tympani nerve, lying as this does far below the surface and well protected from external influences. Usually secretion is induced reflexly from the mucous membrane of the mouth or tongue, the impression made by sapid substances upon the sensory nerves of those parts being transmitted up to the brain and then reflected outwards along the chorda tympani to the gland.

There is, however, yet a third way in which secretion may be induced, and that a somewhat extraordinary one, viz. by paralysis of certain nerves going to the gland instead of by irritation. What the cause of this secretion is has not been clearly made out, but the secretion itself is distinguished by its profusion and long continuance. It has not yet been ascertained whether this kind of secretion is arrested by atropia or not. We propose to ascertain this in future experiments; but as the question did not lie directly within the limits of our present investigation (although closely connected with it), we have not as yet attempted to solve it. There are, then, three ways in which secretion may be induced in the salivary glands:—1st, by direct irritation of the secreting nerves; 2nd, by reflex irritation of these nerves; and 3rd, by paralysis of nerves.

We have entered thus fully on the physiology of secretion in the submaxillary gland, because in it alone has the secreting process and the action of nerves upon it been at all fully studied.

Regarding secretion in the intestines very little is known, but it is probable that the process is performed in much the same way as in the salivary glands.

The reasons for this belief are as follows:—

1st. When the process of digestion is going on and the food is present in the intestines, their vessels are fuller than at other times, just as they are in the salivary glands.

2nd. Stimulation of the mucous surface of the intestine induces secretion of intestinal juice, just as stimulation of the mucous membrane of the mouth induces a flow of saliva.

3rd. Section of all the nerves going to the intestine produces a profuse secretion of intestinal juice, which at once reminds us of the paralytic secretion observed in the submaxillary gland after section of its nerves.

This secretion of the intestine was first discovered by Moreau, who isolated a loop of intestine by means of ligatures, and then divided all the nerves passing to it on their course along the mesentery. On examining the intestine after four hours, the loop which had previously been empty was discovered to be filled with fluid.

This fluid was investigated chemically by Professor Kühne, now of Heidelberg, who found it to be neither more nor less than very dilute intestinal juice and almost identical in composition with the rice-water fluid which is poured from the intestines so abundantly in cholera (Kühne and Parkes).

The intestinal secretion can therefore be excited like the salivary one:—1st, reflexly by stimulation of the mucous membrane of the intestine; and 2nd, by division and consequent paralysis of all the nerves passing to the intestines.

Unlike the salivary secretion, however, it has not yet been induced by direct stimulation of the secreting nerves; and, indeed, these nerves are not yet known. It is not improbable, however, that they are extremely short, and are situated in the walls of the intestine itself, in which, indeed, the whole apparatus necessary to secretion would appear to be contained. This consists of the secreting glands, vessels, and nerves. The nerves immediately inducing secretion are probably the ganglia contained in Meissner's plexus, the short afferent fibres' passing to these from the intestinal mucous membrane, and the short secreting fibres passing from them to the intestinal glands.

The stimuli which excite secretion, when applied to the intestinal mucous membrane, are of various sorts.

Mechanical stimulation, such as tickling the surface of the mucous mem-

branes, at once excites it. The application of dilute hydrochloric acid and induced electrical shocks have a similar effect. Sulphate of magnesia and other purgatives, however, instead of exciting secretion at once, do so only after an interval; and for some time it was supposed that they did not excite secretion at all. The experiments of Moreau, in which he injected magnesium sulphate into a loop of intestine and left it there for four hours, showed that the failure of previous experiments was due to their having applied it to the intestine for too short a time. These experiments were repeated by Vulpian, and also by Brunton, with similar results.

Your Committee, starting from the facts we have briefly enumerated, endeavoured to ascertain, first, whether other neutral salts have a similar effect to magnesium sulphate on intestinal secretion; secondly, whether any other compounds have the power of preventing such action; and thirdly, what are the nerves which regulate this secretion during life.

SERIES I. Action of other neutral salts on intestinal secretion. The method adopted in each case was as follows:—

A cat was chloroformed and an opening was made through the abdominal wall in the middle line. A coil of small intestine was then drawn out through the opening, and four ligatures were tied round it at a distance of 10 centimetres (4 inches) from each other, so as to isolate three pieces of intestine from each other and from the remainder of the intestinal tube. The measured quantity of solution was then injected into the middle loop, either by a very fine Wood's syringe, when the fluid was quite clear, or by making a puncture in the middle loop close to one end, inserting the nozzle of a syringe, and then after the injection of the fluid tying another ligature round the intestine close to the wound so as to prevent the exit of any fluid. This proceeding hardly diminished the length of the loop by more than 3 millimetres ($\frac{1}{8}$ of an inch).

The intestine was then returned to the abdominal cavity, the wound sewn up, and the animal allowed to recover. After about four hours it was killed by a blow on the head with a hammer; the abdominal cavity was opened and the intestine examined.

Experiments were made with potassium acetate, chlorate, ferrocyanide, iodide, sulphate, neutral tartrate, with sodium acetate, bicarbonate, chloride, phosphate, and sulphate, as well as with tartrate of potash and soda. [For particulars see Series I. and Table I. in Appendix.]

From these it appears that several of the other neutral salts possess a similar action to that of magnesium sulphate, though none are so constant or so marked in their action.

The amount of secretion obtained from similar pieces of intestine with similar quantities of the salts differed considerably in different experiments. The cause of this we have not yet determined. It is not improbable that it depends to some extent on the stage of digestion when the injection was made; but this we purpose to ascertain hereafter.

SERIES II. We next tested the effect of various drugs in preventing this action of neutral salts, and for this purpose took a saturated solution of magnesium sulphate as that of which the action is the most constant yet ascertained.

In some cases we mixed the modifying agent with the magnesium sulphate in order to obtain the local action of the drug on the mucous membrane, in others it was introduced into the circulation by subcutaneous injection so as to obtain its general action on the nervous system. The drugs tested in the former way were:—

Gramme.
·32 sulphate of atropia.
·32 iodide of methyl-atropia.
·32 chloral hydrate.
·064 emetia.
·13 morphia.
·32 sulphate of quinine.
·32 tannin.
·064 sulphate of zinc.

Those introduced by subcutaneous injection were,

1 gramme chloral }
·19 do. } Used in cholera by Dr. Hall, of Bengal.
·064 acetate of morphia.

In none of these experiments was there any effect of the above drugs in diminishing the average amount of secretion produced by magnesium sulphate. There appears, therefore, to be no action analogous to that of atropia upon secretion of the submaxillary gland. For summary see Table II. in Appendix.

Direct ligature of the mesenteric veins produced profuse hæmorrhage into the loop of intestine, without any apparent secretion.

Series III. The last point we proposed to investigate was the precise manner in which the nervous system influences secretion.

We first repeated Moreau's experiment by dividing the filaments of nerve in the mesentery which passed to a ligatured loop of intestine. In two cases we obtained a negative result, owing probably to some of the smaller fibres having escaped; but in the third a more successful division was followed by profuse secretion into the loop. This, therefore, is an effect common to cats as well as to dogs and rabbits.

We next divided both splanchnic nerves below the diaphragm; and as this produced no abnormal result on the intestine, we determined to excise the semilunar ganglia (dividing the splanchnics in the same operation).

In 18 experiments we only once found any considerable secretion in the loop of intestine.

The results on the vascularity of the intestines, their peristaltic movements and tonic contraction are given in detail in the Appendix, Series III.

It would appear from these experiments that the splanchnic nerves are not the channel by which currents from the cord pass to the secretory apparatus of the intestine.

What this channel is we hope to ascertain by further investigation, which we intend to apply not only to the secretion but also to the movements of the intestinal tube.

APPENDIX.

Series I.

Experiment 1.—Saturated solution of magnesium sulphate. Three loops were isolated, and $2\frac{1}{2}$ c. c. injected into the middle loop.

On examination,

Middle loop contained 8·5 c. c. of opalescent fluid, which gave an abundant precipitate with HNO_3.

Upper loop }
Lower ,, } empty.

Mucous membrane pale in all loops.

Experiment 2.—Saturated solution of potassium acetate. 5 c. c. were injected into the middle loop.

On examination,

Middle loop contained 8 c. c. blood-stained turbid fluid with very little mucus,
= 7·5 c. c. after filtration. Precipitated by HNO_3.
Upper............ 8 c. c. yellow and turbid,
= 5 c. c. after filtration. Not changed by the addition of HNO_3.
Lower........ = 5·5 c. c.,
= 3·5 c. c. after filtration. Precipitated by HNO_3.

Mucous membrane:—

Middle loop pale, covered with tenacious mucus; serous coat greatly injected.
Upper „ pale.
Lower „ pale, covered with mucus.

Experiment 3.—Saturated solution of potassium acetate. $2\frac{1}{2}$ c.c. were injected into the middle loop. Weight of cat $2\frac{3}{4}$ lbs.

On examination,

Middle loop contained 15·5 c. c. of turbid fluid.
Upper „ empty.
Lower „ about 1 c. c. of mucus.

Mucous membrane:—

Middle loop slightly congested, covered with flakes of mucus. The mucous membrane appeared very thin.
Upper „ normal; bile stained.
Lower „ soft, moist, covered with mucus.

Experiment 4.—Saturated solution of potassium chlorate. Into the middle loop $2\frac{1}{2}$ c. c. were injected.

On examination,

Middle loop } each contained 13 c. c. of a fluid resembling white of
Lower „ } egg, both in colour and consistency.
Upper „ empty.

Mucous membrane:—

Middle loop } normal in colour; soft.
Lower „ }
Upper „ moist, covered with bile-stained matter.

The fluid from the middle and lower loops was not coagulated by heat. It was rendered turbid by HNO_3, and slightly so by acetic acid.

Experiment 5.—Saturated solution of potassium chlorate. Weight of cat 3 lbs. $2\frac{1}{2}$ c. c. of the saturated solution were injected into the middle loop.

On examination,

Middle loop contained 9 c. c. of a grey muddy fluid.
Upper „ „ $\frac{1}{2}$ c. c.
Lower „ „ $\frac{1}{2}$ c. c.

Mucous membrane:—

Middle loop pale, moist.
Upper „ do.
Lower „ do.

Experiment 6.—Saturated solution of potassium ferrocyanide. Three loops were isolated as before; into the middle one $2\frac{1}{2}$ c. c. were injected.

On examination,

Middle loop contained a small quantity of fluid, probably about 5 c. c.; but as the intestine was punctured in opening the abdomen and some of the fluid escaped, it could not be exactly measured, and was estimated approximately. Other loops empty.

Experiment 7.—Saturated solution of potassium ferrocyanide. $2\frac{1}{2}$ c. c. were injected into the middle loop. The cat escaped, and twenty-two hours after was found dead. Weight of cat 3 lbs.

On examination,

Middle loop contained 5·5 c. c. of a purulent-looking fluid.
Upper „ „ 3 c. c. of do. do.
Lower „ empty.

Mucous membrane:—

Middle loop. All the coats deeply congested.
Upper „ } pale.
Lower „ }

Experiment 8.—Saturated solution of potassium ferrocyanide. $2\frac{1}{2}$ c. c. injected into middle loop.

On examination,

Middle loop contained 13 c. c.
Upper „ „ 10 c. c.
Lower „ empty.

The fluid gave no colour with perchloride of iron.

Mucous membrane:—

Middle loop moist, pale.
Upper „ dry, pale.
Lower „ moist; contained a little moist fæcal matter.

Experiment 9.—Saturated solution of potassium iodide. $2\frac{1}{2}$ c. c. injected into middle loop. After tying the ligatures round the intestine, it contracted to the thickness of a pencil. Weight of cat 6 lbs.

On examination,

Middle loop empty; has a hole in it.
Upper „ } both contained about 3 c. c. of fluid.
Lower „ }

Mucous membrane:—

Middle loop. Part of this loop seems to have been eroded by the potassium iodide, causing the formation of a hole in the intestine. The mucous membrane is congested and partly covered with bloody mucus.
Upper „ } pale; normal.
Lower „ }

Experiment 10.—Almost (but not quite) saturated solution of potassium iodide. 5 c. c. injected into the middle loop.

On examination,

Middle loop empty; contained no liquid.
Upper „ } empty.
Lower „ }

Serous coat of middle loop deeply congested and bright red all over.
Upper loop } normal.
Lower „ }

Mucous membrane :—

Middle loop normal, but the deep injection of the submucous coat shines through it.

Upper ,, } normal.
Lower ,, }

Experiment 11.—Nearly saturated solution of potassium iodide. 1 c.c. was injected into the middle loop, and by gentle pressure was brought into contact with the whole of its surface.

On examination,

Middle loop contained 8 c. c.

Upper ,, } empty.
Lower ,, }

Mucous membrane :—

Middle loop congested.

Upper ,, } normal, dry.
Lower ,, }

Experiment 12.—Saturated solution of potassium sulphate. 5 c. c. injected into middle loop.

On examination,

Middle loop contained 14 c. c., which after filtration = 9 c. c.
Upper ,, ,, 3 c. c.
Lower ,, ,, 3 c. c.

Mucous membrane,

Middle loop moist, not congested.

Upper ,, } normal.
Lower ,, }

Experiment 13.—Saturated solution of potassium sulphate. $2\frac{1}{2}$ c.c. injected into middle loop. Weight of cat $4\frac{1}{2}$ lbs.

On examination,

Middle loop contained 9 c. c. of turbid fluid, with many flakes of thick mucus.

Upper ,, } empty.
Lower ,, }

Mucous membrane :—

Middle loop faintly congested, covered with soft flakes of white mucus.
Upper ,, normal, dry.
Lower ,, do. do.

Experiment 14.—Saturated solution of potassium sulphate. 5 c. c. injected into the middle loop.

On examination,

Middle loop contained 14 c. c., which after filtration = 9 c. c.
Upper ,, ,, 3 c. c.
Lower ,, ,, 3 c. c.

Mucous membrane :—

Middle loop moist, not injected.

Upper ,, } normal.
Lower ,, }

Experiment 15.—Saturated solution of potassium tartrate. $2\frac{1}{2}$ c. c. were injected into the middle loop.

On examination,

Middle loop contained 7 c. c. of fluid, which after filtration = $2\frac{1}{2}$ c. c.

Upper „ } empty.
Lower „ }

Experiment 16.—Saturated solution of sodium acetate. $2\frac{1}{2}$ c. c. were injected into the middle loop. Weight of cat $6\frac{1}{2}$ lbs.

On examination,

Middle loop, 10 c. c.
Upper „ 9 c. c.
Lower „ empty.

Mucous membrane:—

Middle loop congested, covered with soft mucus.
Upper „ pale, covered with soft mucus.
Lower „ covered with bile-stained matter.

Experiment 17.—Saturated solution of sodium acetate. 5 c. c. injected into middle loop.

On examination,

Middle loop contained 10 c. c. of fluid, after filtering = 5 c. c.

Upper „ } empty.
Lower „ }

Mucous membrane:—

Middle loop soft, surface exceedingly so.

Upper „ } natural.
Lower „ }

Experiment 18.—Saturated solution of sodium bicarbonate. 5 c. c. of the solution injected into the middle loop.

On examination,

Middle loop contained a tapeworm and some fluid.

	The worm, mucus, and fluid were	=	15 c. c.
	After filtration, the fluid only ..	=	6·5 c. c.
Upper „	contained a worm and fluid	=	8 c. c.
	After filtering	=	6 c. c.
Lower „	empty.		

Mucous membrane:—

Middle loop much congested.
Upper „ much thickened, not congested.
Lower „ natural.

Experiment 19.—Saturated solution of sodium chloride. 5 c. c. of the solution were injected into the middle loop.

On examination four hours after,

Middle (injected) loop contained 10·25 c. c. fluid.
Of this about one third appeared to be thick mucus.

Upper loop } completely empty.
Lower „ }

Mucous membrane:—

Middle loop much thickened and congested.

Upper „ } natural.
Lower „ }

Experiment 20.—Saturated solution of sodium phosphate. $2\frac{1}{2}$ c. c. were injected into the middle loop. The omentum stuck in the wound in the abdo-

minal walls and was caught in the stitches and attached to the wound while it was being sewn up. Weight of cat $4\frac{1}{4}$ lbs.

On examination,

Middle loop contained soft fæces. No fluid.
Upper ,, } dry.
Lower ,, }

The whole intestine was pale.

Middle loop }
Upper ,, } not congested.
Lower ,, }

Experiment 21.—Saturated solution of sodium phosphate. 5 c. c. injected into middle loop.

On examination,

Middle loop contained 11 c. c. blood-stained fluid, which = 5·5 c. c. after filtering.
Upper ,, empty.
Lower ,, 7·5 c. c., = 4 c. c. after filtering.

Mucous membrane :—

Middle loop much congested.
Upper ,, natural; contains a little blood slightly altered.
Lower ,, soft, not congested.

Experiment 22.—Saturated solution of sodium sulphate. $2\frac{1}{2}$ c. c. were injected into the middle loop. Weight of cat 3 lbs.

On examination,

Middle loop contained 18 c. c. of a milky fluid.
Upper ,, ,, 5 c. c.
Lower ,, ,, 3 c. c.

Mucous membrane :—

Middle loop slightly congested, soft, moist.
Upper ,, pale, moist.
Lower ,, do. do.

Experiment 23.—Saturated solution of sodium sulphate. 5 c. c. injected into middle loop.

On examination,

Middle loop contained 9 c. c., after filtering = 7 c. c.
Upper ,, } empty.
Lower ,, }

Mucous membrane :—

Middle loop soft, but not at all congested.
Upper ,, } natural.
Lower ,, }

Experiment 24.—Saturated solution of sodium tartrate. 5 c. c. injected into middle loop.

Middle loop contained 11 c.c. blood-stained fluid, after filtering = 7·5 c.c.
Upper ,, } empty.
Lower ,, }

Mucous membrane :—

Middle loop slightly congested and soft.
Upper ,, } natural; covered with a layer of black fæcal matter.
Lower ,, }

Experiment 25.—Saturated solution of sodium and potassium tartrate. $2\frac{1}{2}$ c. c. were injected into the middle loop. Weight of cat $4\frac{1}{2}$ lbs. The wound

was sewed up as usual, but the sutures gave way, and the intestines protruded for some time before examination.

On examination,

Middle loop contained 16 c. c. of fluid mixed with flakes of soft mucus and small coagula of blood.

Upper „ } each contained about ½ c. c. of soft glairy fluid.
Lower „ }

Mucous membrane :—

Middle loop }
Upper „ } congested.
Lower „ }

TABLE I. *Exhibiting the results of the twenty-five experiments above described.*

Salt injected.	Quantity.	Fluid found in middle loop.
Magnesium sulphate . .	2·5 c. c.	8·5 c. c. opalescent, albuminous.
Potassium acetate	5 „	7·5 „ blood-stained, turbid, albuminous.
Ditto	2·5 „	15·5 „ turbid.
Potassium chlorate . . .	2·5 „	13 „ glairy.
Ditto	2·5 „	9 „ muddy.
Potassium ferrocyanide	2·5 „	5 „ approximately.
Ditto	2·5 „	5·5 „ puriform.
Ditto	2·5 „	13 „
Potassium iodide	2·5 „	. . „ intestine corroded.
Ditto	5 „	. . „ empty.
Ditto	1 „	8 „
Potassium sulphate . .	5 „	9 „ after filtration.
Ditto	2·5 „	9 „ turbid.
Ditto	5 „	9 „ after filtration.
Potassium tartrate	2·5 „	2·5 „ after filtration.
Sodium acetate	2·5 „	10 „
Ditto	5 „	5 „ after filtration.
Sodium bicarbonate . .	5 „	6·5 „ ditto worm present.
Sodium chloride	5 „	10·2 „ ditto about ⅓ mucus.
Sodium phosphate	2·5 „	. . „ no fluid.
Ditto	5 „	5·5 „ blood-stained.
Sodium sulphate	2·5 „	18 „ milky.
Ditto	5 „	7 „
Sodium tartrate	5 „	7·5 „ blood-stained.
Sodium and potassium tartrate	2·5 „	16 „ mucus and blood.

SERIES II.

Experiment 26.—Sulphate of atropia. 2½ c. c. saturated solution of magnesium sulphate mixed with 5 grains of sulphate of atropia were injected into middle loop.

On examination,

Middle loop contained 15·5 c. c. turbid and blood-stained fluid, = 8·5 c. c. after filtration.

Upper „ } empty.
Lower „ }

Mucous membrane :—

Middle loop injected, minute points of ecchymosis.

Upper ,, } pale.
Lower ,, }

Experiment 27.—Iodide of methyl-atropia. $2\frac{1}{2}$ c. c. saturated solution of magnesium sulphate containing 5 grains of iodide of methyl-atropia injected into middle loop.

On examination,

Middle loop contained 6 c. c. opalescent fluid, = 4·5 c. c. after filtration. It gave a copious precipitate with HNO_3.

Upper ,, } empty.
Lower ,, }

Mucous membrane :—

Middle loop injected, with minute ecchymosis, and covered with tenacious mucus.

Upper ,, } pale.
Lower ,, }

Experiment 28.—Chloral hydrate. $2\frac{1}{2}$ c. c. saturated solution of magnesium sulphate containing 5 grs. of chloral hydrate were injected into the middle loop.

On examination,

Middle loop contained 10 c. c. slightly blood-stained fluid, = 9 c. c. after filtration.

Upper ,, } empty.
Lower ,, }

Mucous membrane :—

Middle loop pale.

Upper ,, } pale also.
Lower ,, }

Experiment 29.—Emetia. $2\frac{1}{2}$ c. c. saturated solution of magnesium sulphate with 1 grain of emetia injected into the middle loop.

On examination,

Middle loop contained 12·5 c. c. blood-stained fluid mixed with mucus, = 10 c. c. after filtration. It gave a dense precipitate with HNO_3.

Upper ,, } empty.
Lower ,, }

Mucous membrane :—

Middle loop injected, with minute ecchymosis, covered with thick yellow mucus.

Upper ,, } pale.
Lower ,, }

Experiment 30.—Morphia. $2\frac{1}{2}$ c. c. saturated solution of magnesium sulphate containing 2 grains of morphia were injected into the middle loop.

On examination,

Middle loop contained 7·5 c. c. of clear fluid, with a little mucus; after filtration = 6·5 c. c. It gave no precipitate with HNO_3.

Upper ,, } empty.
Lower ,, }

Mucous membrane :—

Middle loop slightly injected and covered with thin mucus.

Upper ,, } pale.
Lower ,, }

Experiment 31.—Sulphate of quinine. $2\frac{1}{2}$ c. c. saturated solution of magnesium sulphate containing 5 grains of sulphate of quinine were injected into the middle loop.

On examination,

Middle loop contained 19 c. c. of turbid fluid and thick mucus. After filtration it was = 7 c. c. and opalescent. It gave a copious precipitate with HNO_3.

Upper ,, empty.

Lower ,, contained a very little fluid.

Mucous membrane:—

Middle loop slightly injected, covered with gelatinous mucus.

Upper ,, } pale.
Lower ,, }

Experiment 32.—Tannin. $2\frac{1}{2}$ c. c. of a saturated solution of magnesium sulphate containing 5 grains of tannin were injected into the middle loop.

On examination,

Middle loop contained 7 c. c. thick fluid with a granular sediment; no mucus. After filtration = 6 c. c.

Upper ,, contained a tapeworm and a little fluid.

Lower ,, ,, 7·5 c. c., after filtration = 5·5 c. c.

The fluid gave an abundant precipitate with HNO_3.

Mucous membrane:—

Middle loop slightly injected, with extensive submucous extravasation.

Upper ,, } pale.
Lower ,, }

Experiment 33.—Sulphate of zinc. $2\frac{1}{2}$ c. c. saturated solution of magnesium sulphate with 1 grain of zinc sulphate were injected into the middle loop.

On examination,

Middle loop contained 8 c. c. clear fluid, no mucus. It gave an abundant precipitate with HNO_3.

Upper ,, } empty.
Lower ,, }

Mucous membrane:—

Middle loop slightly injected.

Upper ,, } pale.
Lower ,, }

Experiment 34.—Chloral hydrate. $2\frac{1}{2}$ c. c. of a saturated solution of magnesium sulphate were injected into the middle loop, and after closure of the abdominal wound 15 grains (1 gramme) of chloral in 2 c. c. of water were injected subcutaneously. The cat weighed $4\frac{1}{2}$ lbs.

On examination,

Middle loop contained $13\frac{1}{2}$ c. c. of clear fluid with lumps of gelatinous mucus.

Upper ,, } empty.
Lower ,, }

Mucous membrane:—

Middle loop pale, œdematous, covered with soft gelatinous mucus.

Upper ,, } both pale and swollen.
Lower ,, }

Experiment 35.—Chloral hydrate. $2\frac{1}{2}$ c. c. saturated solution of magnesium sulphate were injected into the middle loop, and as soon as the abdominal

wound had been closed, 3 grains of hydrate of chloral in 30 minims of water were injected subcutaneously into the flank of the animal. It weighed $3\frac{1}{2}$ lbs.

On examination,

Middle loop contained $11\frac{1}{2}$ c. c. of clear fluid, with flakes of mucus.

Upper „ } empty.
Lower „ }

Mucous membrane:—

Middle loop moderately injected and covered with mucus. The serous covering of this loop was much injected.

Upper „ } pale.
Lower „ }

Experiment 36.—Acetate of morphia. $2\frac{1}{2}$ c. c. of a saturated solution of magnesium sulphate were injected into the middle loop, and immediately after closure of the abdominal wound 1 grain of acetate of morphia in 2 c. c. of water was injected subcutaneously into the flank of the cat, which weighed 5 lbs.

On examination,

Middle loop contained 10·5 c. c. of turbid fluid, tinged with blood.

Upper „ „ a large tapeworm.

Lower „ empty.

Mucous membrane:—

Middle loop pale, covered with thin gelatinous mucus.

Upper „ } pale.
Lower „ }

Table II. *Exhibiting the results of the Second Series of experiments.*

Drugs injected.	Quantities.	Fluid found in middle loop.
1. Magnesium sulphate .... Atropia sulphate	2·5 c. c. 5 grains	15·5 c. c. turbid, blood-stained, = 8·5 c. c. after filtration.
2. Magnesium sulphate .... Iodide of methyl-atropia.	2·5 c. c. 5 grains	6 c. c. opalescent, albuminous, = 4·5 c. c. after filtration.
3. Magnesium sulphate .... Chloral	2·5 c. c. 5 grains	10 c. c. blood-stained, = 9 c. c. after filtration.
4. Magnesium sulphate .... Emetia	2·5 c. c. 1 grain	12·5 c. c. blood-stained mucus, = 10 c. c. after filtration.
5. Magnesium sulphate .... Morphia	2·5 c. c. 2 grains	7·5 c. c. clear mucus, = 6·5 c. c. after filtration.
6. Magnesium sulphate .... Quinine sulphate	2·5 c. c. 5 grains	19 c. c. turbid fluid and thick mucus, = 7 c. c. after filtration.
7. Magnesium sulphate .... Tannin	2·5 c. c. 5 grains	7 c. c., = 6 c. c. after filtration.
8. Magnesium sulphate .... Zinc sulphate	2·5 c. c. 1 grain	8 c. c.
Subcutaneous injection of chloral, with injection of 2·5 c. c. magnesium sulphate into the loop in each case.		
9. Chloral	1 gram.	13·5 c. c. clear gelatinous mucus.
10. Chloral	·29 „	11·5 c. c. clear fluid, mucus.
11. Morphia acetate	·065 „	10·5 c. c. turbid, blood-stained.

Experiment 37.—Effect of ligature of the mesenteric veins. Three loops of intestine were isolated as usual, but nothing was injected into any of them. The veins passing along the mesentery from the middle loop were carefully isolated and ligatured.

On examination,

Middle loop contained 6·5 c. c. of coagulated blood.
Upper ,, } empty.
Lower ,, }

Mucous membrane and all the coats of the middle loop were intensely congested, the mucous membrane being more so than the other coats. There was very little mucus upon it.

Upper loop } pale.
Lower ,, }

SERIES III.

Experiment 38.—Division of the mesenteric nerves. Three loops were isolated as usual. Nothing was injected, but the nerves passing along the mesentery to the middle one were carefully sought for and divided. No microscopic examination was made afterwards, however, and it is therefore uncertain whether all the filaments were divided or not. The animal weighed 5 lbs.

On examination,

Middle loop }
Upper ,, } all empty.
Lower ,, }

Mucous membrane :—

Middle loop }
Upper ,, } all dry.
Lower ,, }

Experiment 38 *a*.—This experiment was repeated on another animal with a similar result.

Experiment 38 *b*.—Division of the mesenteric nerves. Three loops of intestine were isolated by ligatures. In one of them the vessels were carefully isolated, and the nerves and remaining structures in the mesentery connected with the loop were divided.

On examination,

Operated loop contained 15 c. c. of fluid.
Other loops empty.

Mucous membrane :—

Operated loop somewhat congested.
Other loops normal.

Experiment 39.—Division of both splanchnics. The loops were isolated as usual; nothing was injected into any, but both splanchnic nerves were cut. The animal weighed $5\frac{1}{2}$ lbs.

On examination, about four hours after the operation,

Middle loop }
Upper ,, } all empty.
Lower ,, }

Mucous membrane :—

Middle loop }
Upper ,, } all pale and contracted.
Lower ,, }

Experiment 40.—Extirpation of the upper two thirds of right semilunar ganglion. Division of the right greater splanchnic.

On examination,

Duodenum }
Jejunum } normal.

Lower part of ileum closely contracted.

The loop of ileum 10 centims. long, which had been isolated, was empty.

The part of intestine above the loop was full.

The " " below " empty.

Experiment 41.—Excision of lower two thirds of right semilunar ganglion. Splanchnics not divided. One loop of intestine was isolated.

On examination the intestines were found much contracted. Their diameter was only about half their normal one, and they were also contracted in the direction of their length.

The loop, originally 10 centims., had contracted to 5 centims. The whole intestine was empty.

Experiment 42.—Extirpation (complete) of right semilunar ganglion. In this operation the receptaculum chyli was wounded. The great splanchnic of the right side was divided in removing the ganglion; the lesser splanchnics were unhurt. The animal was in full digestion, and the lacteals and receptaculum were full of milky chyle. The cat was killed about four hours afterwards by a blow on the head.

On examination the whole intestine was normal as regards vascularity and contraction.

One loop of intestine (10 centims. long) had been isolated by ligatures at the time the ganglion was removed. It was situated 35 inches (89 centims.) from the pylorus and 18 inches ($45\frac{3}{4}$ centims.) from the ileo-cæcal valve. The loop was distended with fluid. On measurement this amounted to 13 c. c.

The intestine above the loop did not contain more than 12 c. c. of fluid, although it looked full. The intestine below the loop was empty. There was no worm in the loop. The mucous membrane of the loop was normal.

Experiment 43.—Extirpation of right semilunar ganglion. The right semilunar ganglion was excised as usual, and a loop of intestine 10 centims. long was isolated. On examination about four hours afterwards the whole intestine was normal as regards contraction and vascularity when the abdominal cavity was opened.

After the cavity was opened the intestines contracted; after division of the mesentery they again relaxed, the loop, originally 10 centims., contracting to 7·5 centims., and again relaxing to 10 centims.

The intestines above the loop were empty.

Loop was empty.

Intestines below the loop were full.

Mucous membrane of loop pale, covered with bile-stained mucus.

Experiment 44.—Extirpation of right semilunar ganglion. One loop of intestine isolated in the jejunum and another in the ileum, close to the ileo-cæcal valve.

On examination all the intestine was normal as regards both vascularity and state of contraction.

Jejunal loop }
Iliac " } empty.

Experiment 45.—Extirpation of right semilunar ganglion. The ganglion in this case was reached from the inner side of kidney.

A loop of intestine isolated close to duodenum and another at ileo-cæcal valve.

On examination,

Duodenal loop } both empty.
Iliac ,, }

There were some worms in the duodenal loop and none in the iliac. The latter was more contracted than the former.

Vascularity of intestine normal.

Experiment 46.—Extirpation of right semilunar ganglion. It was cut out from the inner side of the right kidney. One loop of intestine isolated close to the duodenum and another at the ileo-cæcal valve.

On examination,

Jejunal loop contained some worms, but was otherwise empty and dry.
Iliac ,, ,, ½ c. c. of fluid. Its mucous membrane was moist.

Experiment 47.—Excision of left semilunar ganglion and upper two thirds of right ganglion. Section of both greater splanchnics.

On examination,

Duodenum natural.
Jejunum natural.
Ileum pale.

The mucous membrane of the isolated loop was moist and pale. The loop contained about ½ c. c. of fluid.

There were no *Tœniæ* nor *Ascarides* present.

Experiment 48.—Extirpation of both semilunar ganglia. Right semilunar was excised from the inside of the right kidney, and all the nerves attached to it were divided.

One loop of intestine was isolated close to the duodenum, and another near the ileo-cæcal valve.

On examination,

Duodenal loop contained 1 c. c. of fluid.
Iliac ,, ,, 4½ c. c. of pale opalescent fluid. It effervesced and coagulated with nitric acid.

Mucous membrane:—

Duodenal loop swollen, soft, pale.
Iliac ,, pale.

Experiment 49.—Extirpation of both semilunar ganglia, splanchnics on both sides divided, but some small branches of right great splanchnic not divided.

One loop isolated close to the duodenum and another close to the ileo-cæcal valve.

On examination both loops empty.

Vascularity of intestines normal.

Experiment 50.—Extirpation of both semilunar ganglia. The right ganglion was reached from the inside of the right kidney.

One loop of intestine isolated at the upper end of the jejunum and another at the lower end of the ileum.

On examination the whole intestine looked large. Instead of the opposite sides lying flat against each other the intestine was round like a rope.

Jejunal loop contained 1 c. c. of fluid and some fæcal matter.

Iliac loop nearly empty.

Mucous membrane:—
Jejunal loop swollen.
Iliac ,, pale, moist.

Experiment 51.—Excision of semilunar ganglia. Both semilunar ganglia were excised. One loop of jejunum near the duodenum was isolated. When the animal was killed about four hours afterwards, and the intestine examined, it was found to be normal.

The loop contained about 1 c. c. of fluid.

Experiment 52.—Extirpation of semilunar ganglia. Both semilunar ganglia were excised, and one piece of small intestine 10 c. c. long isolated. About four hours after the cat was killed by a blow on the head.

On examination the duodenum was normal.

The jejunum and ileum were shortened and thickened.

The loop, originally 10 centims. long, had shortened to 7·5 centims. On pressing any part of the jejunum or ileum strongly between the fingers the part contracted to half its former diameter, but there was no peristaltic propagation of the contraction. On cutting away the intestine from the mesentery it lengthened, the loop again becoming 10 centims. long. When any part of the intestine was now pressed after its separation from the mesentery, the contraction occurred most strongly at the point of pressure, but it was also propagated to the adjoining portions of intestine.

The mucous membrane of the whole intestine was moist and bile-stained.

The loop contained about 1 c. c. of clear fluid.

Experiment 53.—Excision of semilunar ganglia; division of splanchnics. The splanchnics, large and small, were divided on both sides, and both semilunar ganglia completely excised. Four hours afterwards the cat was killed by a blow on the head.

There was no hyperæmia of the intestine, which was, on the contrary, rather pale. The mucous membrane was pale and dry.

Experiment 54.—Excision of lower two thirds of right semilunar ganglion; division of right splanchnic, with the exception of one or two small communicating branches with left splanchnic and branches to suprarenal capsule.

Two loops of intestine isolated, one at upper end of jejunum, and the other at the lower end of ileum.

On examination both loops were empty.

Mucous membrane in both normal in colour, dry, biliary matter covering its surface.

Experiment 55.—Excision of right semilunar ganglion; division of nerves passing from it around the blood-vessels. Three loops of intestine isolated—one at upper end of jejunum, one at ileo-cæcal valve, and one midway between the two.

On examination all the loops were empty. Mucous membrane normal in all.

Experiment 56.—Excision of the left semilunar ganglion and division of nerves passing from it around the vessels.

Three loops of intestine isolated—one at upper end of jejunum, one at ileo-cæcal valve, and one midway between the two.

On examination all the loops were empty. Mucous membrane normal in all.

All the loops were the same length when tied, viz. 10 centims.

On measurement,

Lower loop, 7·5 centims.
Middle „ 10 „
Upper „ 8·7 „

Experiment 57.—Division of left vagus at the diaphragm. Three loops isolated—one at the upper end of jejunum, one at the ileo-cæcal valve, and one midway between the two.

On examination the stomach was distended with food; contained little fluid. The duodenum appeared full, but on opening it it was found to contain no fluid.

All the loops were empty.

On measurement,

Upper loop, 7·5 centims.
Middle „ 8·7 „
Lower „ 6·2 „

Report of the Committee on the Teaching of Physics in Schools, the Committee consisting of Professor H. J. S. Smith, Professor Clifford, Professor W. G. Adams, Professor Balfour Stewart, Professor R. B. Clifton, Professor Everett, Mr. J. G. Fitch, Mr. G. Griffith, Mr. Marshall Watts, Professor W. F. Barrett, Mr. J. M. Wilson, Mr. Lockyer, *and* Professor G. C. Foster (*Secretary*).

In view of the very great diversities in almost all respects of the conditions under which the work of different schools has to be carried on, the Committee considered that, in any suggestions or recommendations that they might make, it would be impossible for them with any advantage to attempt to enter into details. They have therefore, in the recommendations which they have agreed upon, endeavoured to keep in view certain principles which they regard as of fundamental importance, without attempting to prescribe any particular way of carrying them out in practice.

They have assumed, as a point not requiring further discussion, that the object to be attained by introducing the teaching of Physics into general school-work is the mental training and discipline which the pupils acquire through studying the methods whereby the conclusions of physical science have been established. They are, however, of opinion that the first and one of the most serious obstacles in the way of the successful teaching of this subject is the absence from the pupils' minds of a firm and clear grasp of the concrete facts and phenomena forming the basis of the reasoning processes they are called upon to study. They therefore think it of the utmost importance that the first teaching of all branches of physics should be, as far as possible, of an experimental kind. Whenever circumstances admit of it, the experiments should be made by the pupils themselves, and not merely by the teacher; and though it may not be needful for every pupil to go through every experiment, the Committee think it essential that every pupil should at least make some experiments himself.

For the same reasons, they consider that the study of text-books should be entirely subordinate to attendance at experimental demonstrations or

lectures, in order that the pupils' first impressions may be got directly from the things themselves, and not from what is said about them. They do not suppose that it is possible in elementary teaching entirely to do without the use of text-books, but they think they ought to be used for reviewing the matter of previous experimental lessons rather than in preparing for such lessons that are to follow.

With regard to the order in which the different branches of Physics can be discussed with greatest advantage,—considering that all explanation of physical phenomena consists in the reference of them to mechanical causes, and that therefore all reasoning about such phenomena leads directly to the discussion of mechanical principles,—the Committee are of opinion that it is desirable that the school-teaching of Physics should begin with a course of elementary *mechanics*, including *hydrostatics* and *pneumatics*, treated from a purely experimental point of view. The Committee do not overlook the fact that very little progress can be made in theoretical mechanics without considerable familiarity with the technicalities of mathematics; but they believe that, by making constant appeal to experimental proofs, the study of mechanics may be profitably begun by boys who have acquired a fair knowledge of arithmetic, including decimals and proportion, and as much geometry as is equivalent to the First Book of Euclid. They believe that it will be found sufficient to impart such further geometrical knowledge as may be required (such, for instance, as a knowledge of the properties of similar triangles) in the first instance provisionally, without demonstration, during the course of instruction in mechanics.

In reference to the order in which the other departments of Physics should be studied, the Committee do not think it possible to prescribe any one order that is necessarily preferable to others that might be adopted; but they consider it desirable that priority should be given to those branches in which the ideas encountered at the outset of the study are most easily apprehended, and illustrations of which are most frequently met with in common experience. On these grounds they suggest that the elementary parts of the science of *heat* may advantageously follow mechanics, that elementary *optics* (including the laws of reflexion and refraction, the formation of images, colour, chromatic dispersion, and the construction of the simple optical instruments) should come next, and afterwards the elements of *electricity* and *magnetism**. When it is found possible to include in the work of a school a fuller or more advanced course of Physics than that here indicated, the Committee are of opinion that the discretion of the master, guided by the circumstances of the case, will best decide in what direction the extension should take place; they suggest, however, that an early place in the course should be given to elementary *astronomy*, both because it furnishes the grandest and most perfect examples of the application of dynamical principles, and because it promotes an intelligent interest in phenomena which, in their most superficial aspects, at least, cannot fail to arrest attention, and familiarizes the mind with the wide range of application of physical laws.

The Committee are strongly of opinion that no very beneficial results can be looked for from the general introduction of Physics into school-teaching, unless those who undertake to teach it have themselves made it the subject of serious and continued study, and have also given special attention to the best methods of imparting instruction in it. They therefore suggest that,

* It should be stated that one member of the Committee did not approve of the order of subjects suggested in the text.

with a view to affording facilities to persons desirous of becoming teachers of Physics, of familiarizing themselves with the most efficient methods and of gaining experience in them, the Council of the British Association should invite the leading teachers of Physics in the universities, colleges, and schools of the United Kingdom to allow such persons, under suitable regulations, to be present at the instruction given by them, and, when practicable, to act as temporary assistants. The Committee do not hereby mean that aspirants to the teaching function should be encouraged to drop in at random to hear a lecture by any established teacher who may happen to be within reach; the kind of attendance they have in view would be systematic, and continued for not less than some moderate period of time, such perhaps as two or three months, agreed upon at starting. They believe that the benefits which might result from the adoption of such a plan are very great; the advantages to those who might avail themselves of it are obvious; and while teachers of established success would have a chance of spreading widely their methods of instruction, and, in fact, of founding schools of disciples, the stimulus to exertion, afforded by the consciousness that they were being watched by men who were preparing themselves to occupy positions similar to their own, would be of the most efficient kind.

Preliminary Report of the Committee, consisting of Dr. ARMSTRONG *and* Professor THORPE, *appointed for the purpose of investigating Isomeric Cresols and their Derivatives. Drawn up by* Dr. HENRY E. ARMSTRONG.

A NUMBER of isolated observations have shown that the so-called cresylic acid from coal-tar contains both para- and ortho-cresol, but a satifactory examination of the crude product which would enable us to say that it consists of these two modifications alone has not hitherto been made; moreover, supposing it to contain only these two isomerides, no method is at present known by which it is possible to separate them and obtain each in a state of purity. In conjunction with Mr. C. L. Field your reporter has therefore sought, in the first place, to ascertain what are the constituents of ordinary cresylic acid; and, in the second, to devise a method of separating the isomeric cresols.

The method of examination employed is as follows:—The cresylic acid is heated with an equal weight of concentrated sulphuric acid for 15–20 hours at about 100°; the resulting mixture of sulpho-acids is then thrown into water and neutralized with baric carbonate, and to the solution separated from the precipitated baric sulphate baric hydrate solution is added as long as a precipitate is produced. The basic baric salt of paracresolsulphonic acid thus precipitated is separated from the liquid, decomposed by a slight excess of sulphuric acid, the excess of sulphuric acid is removed by plumbic carbonate and hydric sulphide, and the solution of paracresolsulphonic acid thus obtained neutralized with potassic carbonate. On concentrating the resulting solution potassic paracresolsulphonate, $C_7 H_7 SO_4 K, 2OH_2$, separates out almost in a state of purity.

The solution filtered from the basic baric salt is treated with sulphuric acid, and thus at least two thirds of the barium present removed as sulphate;

potassic carbonate is then added until a precipitate of baric carbonate no longer forms. The solution then contains a mixture of potassic salts of very different solubilities, which may be separated by fractional crystallization. Finally, three products are obtained:—1, potassic phenolparasulphonate; 2, potassic phenolmetasulphonate; 3, which is the most soluble portion, more or less pure potassic orthocresolsulphonate. Hitherto no indication has been obtained of the presence of the third isomeric cresol (*metacresol*) in the coal-tar product; but it is by no means certain, although probable, that this modification is absent. Until characteristic derivatives of this cresol are known this point must remain undecided.

Having thus separated the sulpho-acids derived from the isomeric cresols, it is easy to obtain the corresponding cresols in a state of purity; all that is necessary for this purpose is to heat the sulpho-salt with hydrochloric acid in sealed tubes at about 160° during a couple of hours. The potassic paracresolsulphonate above referred to is thus resolved into paracresol and hydric potassic sulphate; the orthocresolsulphonate into orthocresol and hydric potassic sulphate. In order to purify the cresol thus separated, it is advantageous first to distil it in a current of steam before it is distilled alone. The orthocresol separated from the sulpho-acid gave a large quantity of salicylic acid on fusion with potassic hydrate.

A number of derivatives of paracresol have already been prepared, but their study is as yet by no means completed. On treatment with nitric acid, paracresol yields a mononitrocresol of low melting-point and volatile in a current of steam; a second body, crystallizing in prisms and non-volatile, which is formed simultaneously, is perhaps an isomeric compound. On further treatment with nitric acid the volatile nitrocresol is converted into dinitrocresol (m. p. 81°); this dinitrocresol apparently *cannot* be converted by further nitration into a trinitrocresol. Potassic paracresolsulphonate is readily converted by the action of dilute nitric acid into potassic nitroparacresolsulphonate, which by the continued action of the acid is converted into dinitrocresol (m. p. 81°). Potassic nitroparacresolsulphonate yields on treatment with bromine a dibromonitrocresol, which appears to be isomeric with that obtained on brominating the volatile nitroparacresol previously mentioned. By the action of bromine potassic paracresolsulphonate is successively converted into bromoparacresolsulphonate, dibromoparacresolsulphonate, and finally into tribromocresol.

Considerable quantities of the isomeric cresols having now been obtained from coal-tar by the method above given, it is intended to institute a careful comparative examination of their derivatives.

No portion of the grant made to this Committee having been drawn, it is requested that they be reappointed, and that the same sum be again placed at their disposal.

Third Report of the Committee, consisting of DR. JAMES BRYCE *and* WILLIAM JOLLY, *appointed for the purpose of collecting Fossils from localities of difficult access in North-western Scotland. Drawn up by* WILLIAM JOLLY, *Secretary.*

THE Committee are sorry to have still to report that no organic remains have yet been discovered by them in any locality along the great limestone

strike of the N.W. Highlands, other than the Durness basin, from which the fossils found by the Committee have alone been obtained. The Committee have not been able personally to prosecute the search during the past year, and the Secretary's official work as Inspector of Schools, which formerly extended over the whole of the district of investigation, is now confined to other localities; so that the same active search and personal superintendence of diggings are not now possible. But they have the services of gentlemen resident in the district, who are willing to prosecute the search. The Committee still hope that their labours will have successful results in some of the localities hitherto barren, and this all the more certainly that fossils were discovered by Mr. Peach at Inchnadamph on Loch Assynt.

The Committee beg to propose that the fossils already obtained from this N.W. limestone should be submitted to Mr. Etheridge, Dr. Duncan, Dr. Hicks, or other competent palæontologists, whose report would be presented to the next Meeting of the Association, on the age and species of the fossils, so as, if possible, to lead to a more certain determination of the place in the geologic series of the rocks in which they are found, than was possible with the few and imperfect specimens submitted to Mr. Salter in 1858. The fossils available for this examination consist of:—(1) those collected by the Committee; (2) those collected for Professor Nicol of Aberdeen, and now deposited in the College Museum there; (3) those submitted to Mr. Salter in 1858 and deposited in the Geological Museum in Jermyn Street; and (4) any others that may be obtained by the Committee during the next year. These would form material for a more certain determination of the age of these fossils than has hitherto been possible, as they are both more numerous and more perfect than those originally discovered by Mr. Peach, which were submitted to Mr. Salter and figured in Sir Roderick Murchison's paper on the subject.

The Committee would therefore propose their reappointment by the Association, for the purpose of arranging for this examination and Report, and of prosecuting still further their search in this interesting and important field.

Report on the Rainfall of the British Isles for the years 1873–74, *by a Committee, consisting of* C. Brooke, *F.R.S.*, J. Glaisher, *F.R.S.*, J. F. Bateman, *C.E.*, *F.R.S.*, T. Hawksley, *C.E.*, C. Tomlinson, *F.R.S.*, Rogers Field, *C.E.*, G. J. Symons, *Secretary*.

The attention of your Committee during the past year has been mainly directed to completing work previously commenced, and to the carrying out of all measures likely to tend to still greater accuracy on the part of the observers.

Position Returns.—It will be in the recollection of the members of the Association, that as a partial substitute for the expensive, although most important, practice of personal inspection of rain-gauge stations by our Secretary, we issued (in 1872) to every observer a blank form, on which he was to send full particulars respecting the position of his rain-gauge. A specimen of this form is given in our 1871 Report, page 99. Upwards of 800 were duly filled up by the observers and returned to our Secretary, and they

have all, during the past year, been examined and reduced to the compact form shown on page 259 of our last Report. The number is, however, so great that they would occupy nearly 100 pages of the annual volume, even if further condensed and the utmost economy of space exercised. Your Committee therefore, although fully impressed with the great value of the information which they have thus obtained, do not insert them in the present Report, which is necessarily rather heavy from other causes, and reserve them for next year, when these causes will be absent.

Examination of Rain-gauges in situ.—Your Committee have always regarded this as the most important branch of their work. Only those who have personally inspected large numbers of stations can realize fully the variety of details which it is the duty of an inspector to notice and have rectified. It is worse than useless to collect masses of statistics unless at the same time every effort is made to ascertain that the observations have been in *all* respects properly made. It is therefore with much pleasure that we are able to state that the number of stations visited by our Secretary since the preparation of our last Report is 50, being, as will be seen by the following Table, considerably above the average.

Number of stations inspected and rain-gauges tested *in situ* each year:—

1862 ..	51	1867 ..	50	1871 ..	21
1863 ..	44	1868 ..	40	1872 ..	24
1864 ..	20	1869 ..	115	1873 ..	27
1865 ..	17	1870 ..	39	1874 ..	50 (to Aug. 12th).
1866 ..	60				

The total number tested up to the present time is 558, and they are tolerably well scattered over Great Britain (as was shown by the map exhibited at the Meeting, whereon the locality of each station which has been visited by our Secretary was marked by a *red* disk). We can only once more express our regret that the limit of our grant prevents our providing that which the present system of rainfall observations imperatively requires, viz. one permanent travelling inspector. The results of the inspections since December 4th, 1872, are given in the usual form in the Appendix to this paper. We are glad to state that a steady approach towards accuracy appears to prevail amongst observers, and also a firm conviction that, if it is to be attended to at all, it should receive very careful attention.

List of Stations.—In our last Report we stated that we hoped "at an early date to present a revised edition of the list of stations published in the Report of this Association for 1865," which mainly, in consequence of the work under the auspices of your Committee, had become obsolete, as it does not contain more than two thirds of the data now collected. This work, though mentioned last year for the first time, has been in progress under the supervision of our Secretary for upwards of five years, is now in a forward state, and will form a remarkably complete index of all rainfall observations ever made in this country, and a voluminous one, too, for it would occupy 60 or 70 pages of the annual volume instead of less than 50 pages, as was the case with the last one.

Gauges in the Eastern Lake-district.—In the autumn of 1866 thirteen gauges were placed in the watersheds of Ullswater, Haweswater, Easedale Tarn, &c., by Mr. Symons. These were transferred to your Committee in 1869, and the observations continued at their expense. At their meeting on September 18th, 1873, the Secretary reported that seven years had elapsed since their erection, that several of them were out of order, and new observers

were in charge of others, concerning which personal instruction was desirable. Thereupon he was directed to proceed to the district and take such steps as he thought most expedient for securing accurate observations at a moderate cost. The following is an abstract of his reports:—

The returns from Wet Sleddale have at all times been sent with great irregularity, and for two years none have been received. As a new station had been organized at Shap, that at Wet Sleddale was abandoned. If, however, a good position and a good observer could be obtained in the Sleddale valley, it would be very advantageous.

At Mardale Green the gauge was found to be in perfect order, but the measuring-rod had been broken and clumsily mended; a new one was supplied.

At Measandbecks, Haweswater, the observer had been obliged to move the gauge, and had placed it on ground sloping too precipitously; it was removed a few feet, so as to place it on a level plateau.

The Matterdale Common and Gowbarrow gauges were not visited, as they were repaired some time previously, and the observer reported them to be in perfect order.

Owing to the removal and subsequent death of the observer at the Greenside Mines in Patterdale, the series of observations instituted there, which embraced gauges at 500 feet, 1000 feet, 1550 feet, and 2000 feet, were stopped. Aware of the great importance of accurate observations from that locality, our Secretary visited it, and had the pleasure of finding that the manager of the mines had resumed observations at 1000 feet, the gauge (a very accurate one) being well placed.

The gauges at Wythburn, Easedale Tarn, and Watendlath were in perfect order, and the observations made by the observers originally appointed.

The observer of the gauge at Berkside, Helvellyn, died a few years back, and the gauge had become out of order; the gauge was sent to Keswick for repair, and a new observer instructed in the duties.

The gauges at Seathwaite were in good order, except the large float one, which was repaired at Keswick.

A new observer had been appointed to Kirkstone Pass, who consequently had not received personal instruction; neither of his gauges was in perfect order, but both were put so, and the subsequent records are very satisfactory.

The returns from Skiddaw, though carefully kept, have always been excessively small for the altitude (1677 feet) of the gauge. This is probably due to its very exposed position on the S.W. flank of the mountain. In accordance with a suggestion by the observer (who is on the mountain in all weathers) a second gauge has been placed on Skiddaw, the new site being at the head of Whitbeck.

Map of Stations in operation.—In consequence of the intimation conveyed to your Committee last year, they have discontinued entirely the issue of rain-gauges on loan, and have endeavoured to induce gentlemen to purchase gauges for themselves. With a view to determining the districts in which additional gauges are most needed, a map was prepared, showing the site of every rain-gauge known to be in operation. It will be seen from it, that large as is now our field of operations, there are many districts in which all our efforts to obtain observers have been futile; this is especially the case in the West of Ireland.

Gauges along the Highland Railway.—Your Committee are happy to be able to report that the observations by the station-agents of this Company appear to be carefully and correctly made; but this is another matter which

would be much improved if it were possible to provide a travelling inspector. At present the demands upon the time of our Secretary have been such that he has not been able to visit any of these stations; but he is still hoping shortly to do so. With a view to lessening as far as possible the heavy cost of travelling, your Committee purpose applying to the railway companies for a free pass for their Secretary when travelling for such an essentially national purpose.

Testing Case presented to the Scottish Meteorological Society.—We are glad to say that Mr. Buchan has made very good use of the above; the pressure on his time has prevented his yet forwarding us the details of the examinations of 35 stations visited and tested by him, and of numerous gauges tested before issue; but the work has been done, and the results are promised for our next Report.

Rainfall of the British Isles during the years 1872 *and* 1873.—The very exceptional character of the rainfall of 1872 was mentioned in our last Report; but in accordance with a custom which has now prevailed for twelve years, it was only incidentally referred to, the details being deferred until the two years 1872 and 1873 could be published together. This course, which was originally adopted with a view to economy in printing, has, in the present instance, had the fortunate result of bringing together two very remarkable features, of each of which we must speak separately.

Rainfall of 1872.—Records of rainfall have been collected and discussed in our previous Reports, which enable us to compare the total fall in any year or years from 1726 to the present time with the mean fall. One of these Tables (that facing page 286, British-Association Report, 1866) contains nine long registers, extending over 140 consecutive years; but the greatest excess above the mean, even at a single station, was only 58 per cent. (at Oxford in 1852). In 1872 this value was largely exceeded at a number of stations, as is shown by Tables I. and II., whence it appears that at 14 stations out of 115 (or 12 per cent.), it exceeded this previously unparalleled value. At 13 the excess was greater than 60 per cent., and it reached or exceeded 70 per cent. at the following stations:—

Shropshire	Shiffnal	Rainfall	77	per cent.	above average	1860–69.
„	Shrewsbury	„	75	„	„	„
„	Hengoed, Oswestry	„	70	„	„	„
Northumberland	Bywell	„	77	„	„	„
Haddingtonshire	East Linton	„	70	„	„	„
Aberdeenshire	Braemar	„	78	„	„	„

No similar fall has occurred since 1726, and there is no evidence of such a fall since rainfall observations were commenced nearly two centuries since. Full details respecting the monthly fall of rain in this very remarkable year are given in the Appendix to this Report; and we think it may be regarded as fortunate that so extraordinary a fall has occurred at a period when (owing largely to the operations of this Committee) the system of observation is in a state unprecedentedly near perfection.

The Rainfall of 1873.—If this year had stood by itself, it would merely have been classed as a rather dry year, and would have soon passed into oblivion. Coming, however, immediately after such an exceptionally wet year, it has produced the unusual result of giving two consecutive years, one with twice the rainfall of the other, and in many instances with much more than twice. How rare is this occurrence may be judged from the fact that there is no case in the 140-years Table just referred to. The nearest approaches are, Chatsworth, in 1788 19·86 inches, in 1789 36·31 inches, the

Table I.—Ratio of Rainfall in 1872–73 to Mean of 1860–69.
(See B. A. Report, 1871, p. 106.)

Division.	Stations.	1872.	1873.	Division.	Stations.	1872.	1873.
I.	Camden Square	132	88	XI.	Cardiff	134	91
II.	Croydon	140	94		Rhayader	164	86
	Hunton Court	135	85		Maes-y-dre, Holywell	152	82
	Chilgrove	130	94		Llandudno	155	85
	Dale Park	124	92	XII.	Mull of Galloway	110	60
	Uckfield	124	96		Corsewall	120	77
	Isle of Wight (Osborne)	128	84		Little Ross	151	88
	Aldershot	140	93		Dumfries	136	100
III.	Berkhampstead	133	95		Carlesgill	116	96
	Royston	121	89	XIII.	Bowhill	151	99
	High Wycomb	120	92		Dunse	166	98
	Banbury, High Street	135	87		East Linton	170	122
	Althorpe	153	106		Inveresk	155	97
	Cardington	135	95	XIV.	Bothwell Castle	160	112
	Ely	132	87	XV.	Pladda	132	104
IV.	Witham, Dorward's Hall	148	99		Castle Toward	132	91
	Aldham	139	90		Callton Mor	129	105
	Barton Hall	141	98		Inverary	106	107
	Honingham Hall	143	93		Appin	107	88
V.	Salisbury Plain (Chiltern)	124	85		Mull of Cantire	152	87
	Swindon, Penhill	125	84		Rhinns of Islay	136	108
	Bridport	136	85		Lismore	104	89
	Ham	122	94		Hynish	84	79
	Tavistock, West Street	135	95	XVI.	Isle of May	145	86
	Exeter Institution	145	106		Aberfoyle	134	99
	Broadhembury	140	90		Deanston	132	99
	Barnstaple	145	99		Scone Palace	163	86
	Helston	137	103		Hillhead	148	99
	Truro Institution	124	87		Arbroath	134	100
VI.	Bristol	125	101	XVII.	The Burn, Brechin	151	96
	Ross	147	95		Girdleness	152	103
	Shiffnal	177	99		Braemar	178	128
	Shrewsbury	175	86		Buchanness	115	94
	Oswestry, Hengoed	170	88		Gordon Castle	150	111
	Orleton	143	82	XVIII.	Stornoway	112	96
VII.	Wigston	156	91		Bernera	158	74
	Spalding, Pode Hole	128	78		Portree	82	79
	Lincoln	154	88		Barrahead	128	88
	Welbeck	155	91		South Uist	134	109
	Derby	146	83		Island Glass	157	138
VIII.	Macclesfield	143	94		Culloden	118	105
	Belmont	119	93	XIX.	Golspie	129	123
	Rufford	149	87		Cape Wrath	116	106
	Caton	147	84		Noss Head	133	115
	Coniston	117	80		Pentland Skerries	119	89
IX.	Redmires	151	81		Sandwick	103	97
	Well Head	142	77		Bressay	135	111
	Holbeck	157	77	XX.	Cork	119	94
	York, Bootham	163	77		Waterford	139	99
	Hull	146	88		Killaloe	111	111
	Malton	152	75	XXI.	Woodstock	163	102
X.	Bywell	177	83		Portarlington	102	80
	Wylam Hall	166	71		Tullamore	128	119
	Lilburn Tower	163	83		Black Rock	156	92
	Seathwaite	118	93	XXIII.	Enniskillen	138	90
	Keswick Post Office	133	88		Armagh	124	84
	Kendal, Kent Terrace	130	93		Belfast	130	91
	Appleby	128	81				

TABLE II.—Mean and Extreme Ratios in each Division.

Abstract of Table I.

Division.	Description.	Number of Stations.	Ratio for 1872.			Ratio for 1873.		
			Mean.	Highest.	Lowest.	Mean.	Highest.	Lowest.
	ENGLAND AND WALES.							
I.	Middlesex	1	132	132	132	88	88	88
II.	South-Eastern Counties	7	132	140	124	91	96	84
III.	South Midland Counties	7	133	153	120	93	106	87
IV.	Eastern Counties	4	143	148	139	95	99	90
V.	South-Western Counties	10	133	145	122	93	103	84
VI.	West Midland Counties	6	156	177	125	92	101	82
VII.	North Midland Counties	5	148	156	128	86	91	83
VIII.	North-Western Counties	5	135	149	117	88	94	80
IX.	Yorkshire	6	152	163	142	79	88	75
X.	Northern Counties	7	138	177	118	83	93	71
XI.	Monmouthshire, Wales, &c.	4	151	164	134	86	91	82
	SCOTLAND.							
XII.	Southern Counties	5	127	151	110	84	100	60
XIII.	South-Eastern Counties	4	161	170	151	104	122	97
XIV.	South-Western Counties	1	160	160	160	112	112	112
XV.	West Midland Counties	9	120	152	84	95	108	79
XVI.	East Midland Counties	6	143	163	132	95	100	86
XVII.	North-Eastern Counties	5	149	178	115	106	128	94
XVIII.	North-Western Counties	7	127	158	82	98	138	74
XIX.	Northern Counties	6	123	135	103	107	123	89
	IRELAND.							
XX.	Munster	3	123	139	111	101	111	94
XXI.	Leinster	4	137	163	102	98	119	80
XXIII.	Ulster	3	131	138	124	88	91	84
	Mean	Total 115	139	155	122	94	104	84
	Maximum		161	178	160	112	138	112
	Minimum		120	132	82	79	88	60

former being 55 per cent. of the latter. A still nearer approach occurred at Cobham, in Surrey, in 1851 and 1852, when the totals were 17·38 inches and 34·19 inches respectively, the former being 51 per cent. of the latter. In Table III. no cases are admitted unless much more striking than the above. The districts in which these exceptional ratios occur are (as might be expected) principally those in which the excess in 1872 was greatest; but there are also a few of which the explanation is not so obvious. It is very satisfactory to feel that these two exceptional years have found in the British Isles the most nearly perfect system of observation in the world.

Your Committee cannot close their Report without expressing, as far as words can do so, the loss which they have sustained in the death of Professor Phillips, one of the original members appointed in 1865, who, notwithstanding the numerous other demands upon his time, was always as willing as he was able to assist the Committee in any of the various difficulties which the extent of their operations inevitably involve.

TABLE III.—Comparison of total Rainfall in 1872 and 1873 at Stations where the fall in the latter year was less than half that of 1872.

Division.	Station.	Total Fall, 1872.	Total Fall, 1873.	Per cent. of 1872.
		in.	in.	
VI.	Leysters, Leominster	54·03	26·82	49
	Craven Arms, Stokesay	50·87	25·32	50
	Shrewsbury	34·15	16·70	49
	Newport, Cheswell Grange	46·36	22·83	49
	Whitchurch	55·03	26·87	49
	Penkridge, Rodbaston	48·16	23·96	50
VIII.	Chester, Pulford Hall	48·31	21·21	44
	Bosley Minns	51·87	25·65	50
	Chester, Newton Nurseries	52·02	24·49	47
	Neston, Hinderton	45·45	21·74	48
	Marple Top Lock	54·35	26·53	49
IX.	Handsworth Grange, Sheffield	37·60	17·65	47
	Broomhall Park, Sheffield	45·81	22·40	49
	Crookes, Sheffield	43·00	21·41	50
	Tinsley Locks, Sheffield	45·91	21·54	47
	Moorgate Grove, Rotherham	39·26	17·63	45
	Wath-upon Dearne, Rotherham	40·16	16·92	42
	West Melton, Rotherham	39·53	16·84	43
	Elsecar, Barnsley	41·07	18·79	46
	Doncaster	42·29	19·39	46
	„ (Magdalens)	38·39	18·18	47
	Worsborough, Barnsley	56·86	22·33	39
	Dunford Bridge Station	85·74	42·44	49
	Penistone	54·42	25·78	47
	Barnsley	42·28	15·90	38
	„ Church Street	45·54	18·45	40
	Ackworth	41·07	19·07	47
	Mirfield	37·45	18·65	50
	Rastrick, Huddersfield	43·44	19·31	44
	Bradford Mechanics' Institution	43·12	19·96	46
	„ (Chellow Dean)	51·52	24·75	48
	Holbeck, Leeds	35·90	17·50	49
	Bootham, York	39·97	18·80	47
	Cherry Hill, York	40·38	19·87	49
	Ripon, Littlethorpe	42·68	20·52	48
	„	42·07	19·63	47
	Thicket Priory, Thorganby	34·05	16·73	49
	Malton	41·79	20·71	50
	Filey	46·81	21·07	45
	Thorpe Perrow, Bedale	44·22	19·29	44
	Leyburn	49·66	21·53	43
	Northallerton	40·53	19·92	49
	Tunstall, Catterick	42·10	19·05	45
	Grosmont	57·18	18·88	33
	Whitby, North Lighthouse	39·95	17·04	43
	„ Guisborough Road	38·62	19·07	49
	Greta Bridge	44·75	20·80	46
	Grey Towers, Middlesborough	41·82	17·18	41
	Marton Hall, „	40·64	19·20	47
	Upleatham	36·25	17·30	48
	Middlesborough	34·70	15·86	46
X.	Eaglescliffe [Yarm]	39·46	19·69	50
	Whorlton	41·69	20·21	49
	Sedgefield	39·34	19·67	50
	Wolsingham	53·80	24·98	46
	Durham Observatory	48·47	22·99	47
	Seaham Vicarage	41·62	20·27	49
	Shotley Hall	48·03	21·67	45
	Bywell	51·16	24·00	47
	Wylam Hall	44·64	19·16	43
	Newcastle, Rye Hill	41·56	20·43	49
	„ Philosophical Society	41·33	19·02	46
	„ Town Moor	41·49	20·35	49
	North Shields, Whitley	39·97	19·87	50
	Glanton Pyke	50·87	23·42	46

TABLES OF MONTHLY RAIN-

ENGLAND.

	Division I.—Middlesex.								Div. II.—S.E. Counties.			
	Middlesex.								Surrey.			
Height of Rain-gauge above	Camden Square.		Upper Clapton.		Hampstead, Squire's Mount.		Winchmore Hill.		Dunsfold, Godalming.		Weybridge Heath.	
Ground ...... Sea-level......	0 ft. 6 in. 111 ft.		1 ft. 1 in. 98 ft.		1 ft. 0 in. 388 ft.		1 ft. 0 in. 350 ft.		2 ft. 6 in. 166 ft.		0 ft. 6 in. 150 ft.	
	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	3·46	2·44	3·33	2·36	3·48	2·34	3·92	2·76	5·82	3·84	4·01	2·68
February ...	·96	1·96	·81	1·36	·85	1·28	·98	2·29	2·04	2·06	1·22	1·95
March	2·66	1·46	2·50	1·44	2·37	1·54	2·95	1·86	2·32	1·62	1·85	1·64
April	1·39	·55	1·41	·67	1·57	·56	1·43	·66	·97	·70	1·10	·66
May	3·05	1·56	2·90	1·88	3·27	1·73	3·45	2·25	2·96	1·40	3·38	1·57
June	2·55	2·24	1·99	2·32	2·30	2·24	3·31	2·31	2·54	2·03	2·39	1·54
July	2·57	1·81	2·55	1·63	2·61	1·99	3·38	2·08	2·47	1·96	3·63	1·48
August	2·05	2·87	2·74	2·35	2·22	3·06	2·61	2·54	2·27	1·44	1·88	1·89
September ...	1·64	2·46	1·30	2·29	1·54	3·03	1·60	3·26	1·73	2·78	1·27	2·44
October	5·20	2·97	4·42	2·84	5·52	3·20	5·40	2·84	5·60	3·07	4·45	3·22
November ...	3·98	1·87	3·39	1·80	3·55	1·95	4·09	2·10	5·03	2·49	3·36	2·19
December ...	4·35	·48	4·19	·31	4·31	·60	4·73	·51	4·71	·50	4·03	·38
Totals......	33·86	22·67	31·53	21·25	33·59	23·52	37·85	25·46	38·46	23·89	32·57	21·64

	Division II.—South-Eastern Counties (*continued*).											
	Kent (*continued*).						Sussex.					
Height of Rain-gauge above	River Head, Sevenoaks.		Acol, Margate.		Sidcup, Foot's Cray.		Brighton, Lewes Road.		Chichester Museum.		Bleak House, Hastings.	
Ground ...... Sea-level......	1 ft. 0 in. 520 ft.		1 ft. 0 in. 70 ft.		0 ft. 8 in. 231 ft.		3 ft. 9 in. 90 ft.		0 ft. 6 in. 50 ft.		1 ft. 0 in. 80 ft.	
	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	6·62	4·21	2·32	1·48	4·01	2·32	5·64	3·01	5·20	3·39	4·83	3·25
February ...	1·80	2·50	·48	1·52	·75	2·33	2·62	1·83	1·98	2·90	1·50	1·94
March	2·59	2·01	1·60	1·06	2·09	1·39	2·49	2·06	2·69	2·25	2·28	2·34
April	1·18	1·07	1·25	1·22	1·07	·66	·85	·97	·84	1·02	·86	·83
May	3·69	1·60	3·01	1·20	4·17	·96	3·14	1·03	2·70	·97	2·22	1·13
June	2·88	2·48	2·81	1·04	1·62	1·93	2·66	2·30	1·94	1·96	2·08	2·31
July	2·58	2·18	3·00	1·15	2·44	2·20	1·38	1·93	3·05	1·77	1·79	1·13
August	2·21	3·62	2·23	1·50	1·76	3·06	2·15	3·54	2·57	1·74	1·45	2·00
September ...	2·07	2·65	1·29	1·71	1·40	1·85	2·33	3·22	1·42	2·31	2·35	2·39
October	5·23	4·00	3·53	3·16	5·26	3·35	5·36	4·69	4·98	3·18	5·73	3·89
November ...	5·84	3·15	5·52	1·54	3·24	2·32	6·46	3·39	4·86	2·36	6·92	2·56
December ...	5·96	·76	4·71	·31	3·94	·42	5·61	·78	4·70	·56	5·97	·59
Totals......	42·65	30·23	31·75	16·89	31·75	22·79	40·69	28·75	36·93	24·41	37·98	24·36

FALL IN THE BRITISH ISLES.

ENGLAND.

Division II.—South-Eastern Counties (*continued*).

Surrey (*continued*).						Kent.							
Chobham.		Kew Observatory.		Kennington Road.		Dover Castle.		Hythe.		Linton, Maidstone.		Falconhurst, Edenbridge.	
1 ft. 2 in. 93 ft.		1 ft. 3 in. 19 ft.		5 ft. 0 in. 19 ft.		1 ft. 6 in. 32 ft.		0 ft. 6 in. 12 ft.		0 ft. 6 in. 296 ft.		1 ft. 0 in. 400 ft.	
1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
4·20	2·50	3·43	2·15	2·71	1·99	4·45	3·18	5·03	3·35	4·68	2·69	6·15	3·65
1·28	1·92	·81	1·57	·85	1·80	1·34	2·20	1·54	2·28	1·33	2·24	1·65	2·19
1·53	1·70	1·74	1·37	1·82	1·04	2·41	1·82	2·93	2·27	1·93	1·66	2·52	2·27
1·12	·24	1·43	·41	·97	·77	1·64	1·42	1·97	1·50	1·56	·81	·83	1·08
2·95	1·41	2·95	1·32	3·16	1·41	3·79	2·05	3·26	2·09	4·35	·97	2·48	1·40
2·06	1·35	1·48	2·79	·75	2·57	2·68	2·35	2·57	1·63	4·13	3·70	2·18	2·88
4·10	2·47	1·81	1·98	3·06	1·52	3·30	1·02	2·56	2·08	2·21	1·60	1·78	2·02
1·55	1·81	1·45	1·84	2·61	3·41	1·95	2·12	1·57	3·39	1·35	2·13	1·74	2·79
1·44	2·25	1·29	2·11	1·23	2·23	1·89	2·45	2·11	3·63	2·01	2·69	2·13	2·38
4·43	2·66	4·31	2·91	4·27	2·75	6·08	4·61	4·66	4·17	4·48	3·31	6·16	4·41
3·53	1·82	2·96	1·96	3·18	1·95	10·44	2·96	8·53	2·87	5·81	1·73	5·50	2·47
4·14	·42	3·73	·40	3·71	·32	6·61	·90	7·58	1·25	5·26	·46	4·95	·64
32·33	20·55	27·39	20·81	28·32	21·76	46·58	27·08	44·31	30·51	39·10	23·99	38·07	28·18

Division II.—South-Eastern Counties (*continued*).

Sussex (*continued*).												Hampshire.	
Dale Park, Arundel.		Battle.		Uckfield Observatory.		Chilgrove, Chichester.		Balcomb Place, Cuckfield.		Petworth Rectory.		St. Lawrence, Isle of Wight.	
3 ft. 5 in. 316 ft.		1 ft. 3 in.		6 ft. 0 in. 149 ft.		0 ft. 6 in. 284 ft.		1 ft. 3 in. 300 ft.		2 ft. 0 in. 190 ft.		1 ft. 0 in. 75 ft.	
1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
7·30	4·86	5·37	3·68	5·36	3·60	7·42	4·91	6·92	4·11	7·05	5·11	5·84	4·24
2·14	2·10	1·91	2·22	1·80	2·02	2·83	3·20	2·38	2·70	2·30	2·77	2·06	3·04
1·40	2·40	2·59	2·87	1·94	2·18	2·77	2·44	3·11	1·85	2·81	2·39	3·60	2·35
1·23	·65	1·11	1·02	·61	·64	·96	·74	·64	·68	·79	·68	1·31	·72
3·61	1·10	2·95	1·36	3·16	1·02	2·82	1·46	4·87	1·28	3·10	1·08	2·76	·89
2·10	2·50	2·77	2·67	2·72	2·79	2·03	2·52	2·95	2·63	3·12	2·85	1·88	2·15
2·70	2·52	2·21	1·78	1·59	2·35	3·02	2·60	2·91	2·49	4·35	2·48	3·23	1·84
2·00	3·15	1·88	2·54	1·80	3·62	1·60	2·03	1·26	4·15	1·87	1·72	1·09	1·57
1·67	2·60	2·80	2·59	1·83	3·07	2·54	3·16	2·01	2·62	2·11	2·81	1·70	2·38
7·55	4·05	5·95	4·59	5·03	4·67	5·97	4·49	6·33	5·64	7·04	4·57	5·15	5·03
5·37	3·70	7·08	2·61	6·92	3·16	5·39	2·90	6·13	2·48	5·02	3·02	5·31	2·99
4·65	1·25	6·86	·84	5·88	·94	5·86	·72	5·10	·64	5·33	·64	6·02	·85
41·72	30·88	43·48	28·77	38·64	30·06	43·21	31·17	44·61	31·27	44·89	30·12	39·95	28·05

ENGLAND.

Division II.—South-Eastern Counties (*continued*).

Hampshire (*continued*).

Height of Rain-gauge above	Ryde, Isle of Wight.		Osborne, Isle of Wight.		Fareham.		Otterbourne, Winchester.		Selborne.		Liss, Petersfield.	
Ground	7 ft. 0 in.		0 ft. 8 in.		10 ft. 0 in.		1 ft. 3 in.		4 ft. 0 in.		0 ft. 7 in.	
Sea-level	20 ft.		172 ft.		36 ft.		115 ft.		400 ft.		250 ft.	
	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	6·30	4·87	5·68	4·62	5·60	4·25	6·00	3·73	7·87	5·38	9·73	6·76
February	1·95	3·95	2·28	2·77	1·07	1·44	2·14	1·82	3·10	2·60	2·79	2·05
March	3·16	2·29	2·68	2·10	3·17	3·74	2·84	2·36	3·02	2·95	4·21	2·87
April	1·05	1·22	1·05	1·25	1·10	1·00	1·56	·79	1·49	·54	1·67	·68
May	2·83	1·02	2·28	1·00	2·41	1·27	2·59	1·43	3·40	1·90	3·34	1·35
June	2·24	1·49	2·40	1·54	3·07	1·73	3·61	1·40	3·68	1·53	2·85	1·70
July	3·18	2·64	2·84	1·96	1·18	2·55	3·00	2·02	3·48	3·48	5·68	3·19
August	1·32	1·38	1·86	1·65	2·07	2·28	1·86	2·71	2·03	2·36	2·02	1·92
September	2·02	2·30	1·97	2·45	2·83	2·85	1·72	2·77	2·27	3·19	2·13	2·69
October	5·56	3·81	5·88	3·71	4·41	2·88	5·62	2·93	6·81	3·72	7·55	4·17
November	5·52	1·83	5·46	2·00	4·89	3·09	4·34	2·18	5·78	2·61	5·40	2·80
December	6·10	·67	5·00	·74	4·61	·47	5·83	·53	6·63	·56	6·44	·65
Totals	41·23	27·47	39·38	25·79	36·41	27·55	41·11	24·67	49·56	30·82	53·81	30·83

Division III.—South Midland Counties (*continued*).

	Buckinghamshire.		Northampton.				Bedford.		Cambridge.			
Height of Rain-gauge above	High Wycomb.		Althorpe House.		Wellingborough.		Cardington.		Wisbeach.		Stretham, Ely.	
Ground	0 ft. 9 in.		3 ft. 10 in.		0 ft. 1 in.		0 ft. 0 in.		0 ft. 6 in.		4 ft. 9 in.	
Sea-level	225 ft.		310 ft.		....		106 ft.		10 ft.		....	
	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	4·31	3·53	3·56	2·14	2·88	2·01	2·75	2·15	2·54	1·88	1·81	1·44
February	1·69	1·87	1·74	1·26	1·53	1·29	1·10	1·46	1·31	1·69	·74	·59
March	2·20	2·34	1·87	2·06	1·70	1·43	1·75	1·46	2·44	1·56	1·45	1·02
April	1·50	·37	2·87	·59	2·71	·79	1·90	1·20	4·03	1·06	1·82	·85
May	2·26	1·56	1·63	2·45	2·13	2·33	2·08	2·00	2·15	2·84	2·32	1·80
June	2·72	1·80	3·41	4·82	2·99	3·20	2·50	2·35	2·97	1·60	2·43	1·57
July	2·12	1·87	4·66	1·90	3·76	2·02	4·30	2·00	5·93	2·51	4·05	1·95
August	1·46	2·19	2·70	3·05	2·74	2·32	3·00	2·20	4·48	4·02	2·35	2·31
September	·81	2·85	1·54	1·21	1·36	1·04	1·15	1·90	2·49	1·87	1·54	2·02
October	3·62	2·68	3·91	2·20	3·60	2·08	3·15	2·15	3·35	2·39	3·03	2·48
November	3·75	2·03	4·03	2·33	3·68	1·75	3·36	2·00	3·50	1·42	3·49	1·47
December	4·37	·43	3·70	·65	3·09	·51	3·20	·50	3·27	·55	2·17	·53
Totals	30·81	23·52	35·62	24·66	32·17	20·77	30·24	21·37	38·46	23·39	27·20	18·03

ENGLAND.

Division II.—South-Eastern Counties (*continued*).				Division III.—South Midland Counties.									
Hampshire (*continued*).		Berkshire.		Hertfordshire.						Oxfordshire.			
Aldershot.		Long Wittenham.		Berkhampstead.		Royston.		Hitchin.		Radcliffe Observatory.		Banbury.	
6 ft. 0 in. 316 ft.		1 ft. 0 in. 70 ft.		1 ft. 6 in. 370 ft.		0 ft. 6 in. 266 ft.		1 ft. 0 in. 238 ft.		0 ft. 11 in. 208 ft.		7 ft. 0 in. 350 ft.	
1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
5·61	3·87	4·42	3·42	5·07	4·44	2·92	2·64	3·74	2·80	4·06	2·20	4·27	2·45
2·07	2·18	1·36	1·30	1·70	1·76	1·09	2·32	1·25	1·64	1·50	1·52	1·88	1·50
2·15	2·28	1·44	2·09	2·42	2·47	2·11	1·49	1·97	1·52	1·77	2·34	2·11	2·22
1·40	·53	2·18	·79	1·92	·85	1·81	·74	1·88	·83	1·87	·48	2·15	·44
2·51	1·14	2·44	1·74	3·25	2·46	2·75	1·70	3·01	1·80	2·55	2·30	1·11	2·48
2·60	1·49	2·29	2·37	3·62	2·06	2·70	1·09	2·47	1·68	2·87	2·78	2·76	3·68
2·57	2·03	3·68	1·50	3·18	2·84	2·76	1·45	2·27	1·99	2·91	2·22	4·43	2·18
2·12	1·86	1·88	2·31	2·29	2·06	1·95	2·94	1·50	2·17	1·16	2·62	2·84	2·61
1·44	2·49	1·05	1·99	1·37	2·96	·88	1·90	·69	2·49	·97	1·82	1·46	1·49
4·62	2·54	2·94	2·40	4·75	2·95	3·39	2·36	3·73	2·48	2·89	2·69	3·45	1·84
3·20	2·26	2·34	2·11	4·45	2·23	2·74	1·96	3·43	1·87	3·13	1·70	4·87	1·13
4·65	·64	3·68	·52	4·95	·70	3·42	·50	3·78	·60	3·79	·51	4·00	·80
34·94	23·31	29·70	22·54	38·97	27·78	28·52	21·09	29·72	21·87	29·47	23·18	35·33	22·82

Division IV.—Eastern Counties.													
Essex.										Suffolk.			
The Hemnalls, Epping.		Dorward's Hall, Witham.		Dunmow.		Bocking, Braintree.		Ashdon Rectory.		Grundisburgh.		Culford, Bury St. Edmund's.	
0 ft. 8 in. 345 ft.		1 ft. 6 in. 20 ft.		0 ft. 0 in. 234 ft.		4 ft. 0 in. 200 ft.		1 ft. 6 in. 300 ft.		3 ft. 9 in.		1 ft. 6 in.	
1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
4·02	2·86	3·08	1·57	3·53	3·02	3·94	2·96	3·08	3·12	3·77	1·93	2·83	1·91
1·01	1·94	·86	1·63	·92	1·65	·87	1·99	·89	1·70	·66	1·91	·90	1·88
2·84	1·48	2·59	1·43	1·96	1·33	2·60	1·49	2·69	1·48	3·22	1·44	2·50	1·66
1·90	1·07	1·35	·56	2·30	1·12	2·00	·99	1·75	·90	2·35	1·00	1·86	1·31
3·71	1·86	3·05	1·27	2·42	1·54	2·71	1·50	1·96	1·75	2·82	1·90	2·53	2·06
2·86	1·89	2·56	2·35	2·94	2·66	2·65	4·29	2·87	2·09	3·74	1·69	2·01	2·50
3·77	2·08	3·46	1·83	3·04	1·77	4·48	1·45	5·08	2·16	2·72	1·73	6·21	2·23
2·00	3·43	2·40	2·50	1·70	1·69	1·64	1·94	1·12	1·80	1·59	1·33	2·49	2·19
1·50	2·96	1·15	2·53	1·38	2·55	1·89	3·09	1·27	2·89	2·03	2·45	2·35	2·72
4·61	2·78	3·35	2·15	4·45	2·62	3·75	2·33	3·66	2·54	4·32	2·12	3·12	3·57
3·51	2·06	3·07	1·93	2·82	2·14	3·20	1·71	3·40	2·40	4·75	1·53	4·01	2·00
4·43	·48	3·37	·43	4·08	·46	3·67	·52	3·90	·54	3·25	·52	3·83	·69
36·16	24·89	30·29	20·18	31·54	22·55	33·40	24·26	31·67	23·37	35·22	19·55	34·64	24·72

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	Division IV.—Eastern Counties (*continued*).								Division V.—South-Western Counties.			
	Norfolk.								Wilts.			
Height of Rain-gauge above	Geldeston, Beccles.		Cossey, Norwich.		Swaffham.		Holkham.		Wilton, Salisbury.		Marlborough College.	
Ground ...... Sea-level......	1 ft. 0 in. 40 ft.		1 ft. 0 in.		1 ft. 0 in. 160 ft.		0 ft. 0 in. 39 ft.		0 ft. 5 in. 180 ft.		0 ft. 0 in. 456 ft.	
	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	2·78	1·90	2·05	1·99	2·63	2·20	2·10	1·80	7·33	5·59	6·84	4·38
February ...	·98	1·49	·93	1·90	1·40	1·84	·83	3·18	2·82	1·92	2·65	1·40
March	2·76	1·52	3·96	2·02	2·29	1·88	2·30	1·72	3·05	3·25	2·39	2·79
April	2·05	1·07	2·26	1·34	2·53	1·27	2·60	1·07	2·21	1·01	1·96	1·25
May	2·47	1·49	2·08	1·88	2·25	2·28	1·70	2·10	2·81	1·35	2·30	1·89
June	2·44	1·73	3·13	1·67	4·72	1·54	1·75	1·15	3·49	2·45	3·41	1·63
July	4·60	2·24	3·29	1·98	5·89	1·95	3·50	2·00	3·00	1·39	2·63	2·15
August	2·20	·85	3·67	2·03	4·21	1·90	6·23	1·75	2·43	2·65	2·32	2·52
September ...	1·94	2·03	2·81	3·02	3·13	3·02	2·65	2·75	1·77	1·99	1·08	3·14
October	3·08	2·69	3·15	2·29	2·84	2·42	2·55	2·15	5·89	1·98	5·67	2·63
November ...	5·17	·76	4·17	1·28	4·28	1·37	3·85	1·15	5·49	3·39	5·23	3·33
December ...	3·44	·39	3·74	·66	3·96	·76	3·38	·60	5·72	·93	5·51	·60
Totals	33·91	18·16	35·24	22·06	40·13	22·43	33·44	21·42	46·01	27·90	41·99	27·71

	Division V.—South-Western Counties (*continued*).											
	Devonshire (*continued*).											
Height of Rain-gauge above	Landscore, Teignmouth.		Broadhembury, Honiton.		Cove, Tiverton.		Castle Hill, S. Molton.		Great Torrington.		Barnstaple.	
Ground ...... Sea-level......	0 ft. 6 in. 200 ft.		1 ft. 6 in. 400 ft.		0 ft. 4 in. 450 ft.		4 ft. 0 in. 200 ft.		1 ft. 1 in. 323 ft.		1 ft. 0 in. 31 ft.	
	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	7·50	6·79	5·46	4·66	7·17	5·78	7·55	4·87	6·31	6·02	5·98	5·43
February ...	4·72	3·55	4·26	2·09	6·40	2·33	5·30	·16	4·91	3·48	4·64	2·29
March	3·37	5·33	2·73	4·16	3·39	4·78	3·91	3·21	4·81	3·28	3·74	3·77
April	2·99	1·17	2·71	1·00	2·78	1·19	3·52	1·84	3·11	1·16	2·68	1·11
May	2·07	1·91	2·25	1·25	2·26	2·10	2·60	2·95	1·85	1·92	1·93	2·30
June	3·04	1·09	4·58	1·83	2·87	1·10	4·52	1·84	4·79	1·62	5·32	1·50
July	4·05	2·17	4·77	1·95	3·36	3·33	7·39	5·51	4·10	4·35	6·35	4·50
August	1·42	4·35	1·40	4·82	2·38	4·50	4·15	7·47	2·73	5·76	2·82	7·19
September ...	3·05	3·01	3·28	2·26	3·66	2·82	4·79	4·86	4·37	3·22	5·14	3·16
October	5·19	1·98	5·86	2·03	6·43	3·66	8·67	4·62	7·49	4·83	7·38	4·46
November ...	4·99	4·55	4·70	4·57	6·23	4·07	6·38	2·84	6·30	3·44	6·27	2·14
December ...	7·23	·51	6·32	·43	8·28	1·05	6·04	1·45	6·43	1·13	5·71	1·45
Totals......	49·62	36·41	48·32	31·05	55·21	36·71	64·82	41·62	57·20	40·21	57·96	39·30

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Division V.—South-Western Counties (*continued*).

Wilts (*continued*).		Dorset.						Devonshire.					
Chippenham, Tytherton.		Longthorns.		Upwey.		Bridport.		Saltram Gardens.		Totness.		Dartmoor Reservoir.	
1 ft. 2 in. 150 ft.		0 ft. 4 in. 360 ft.		1 ft. 0 in. 70 ft.		0 ft. 8 in. 63 ft.		0 ft. 3 in. 95 ft.		1 ft. 0 in. 120 ft.		0 ft. 2 in. 1400 ft.	
1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
4·46	3·17	8·80	6·01	6·48	4·46	5·94	3·88	8·71	7·90	11·82	8·99	11·21	10·89
2·63	1·16	4·20	2·42	2·51	3·81	2·53	3·17	6·03	3·75	6·54	4·33	8·99	6·99
1·74	2·76	4·27	4·75	3·14	3·84	3·00	3·04	5·37	4·85	5·30	5·90	6·16	6·59
2·28	·79	3·05	1·05	2·52	·67	2·18	·78	·65	·54	2·81	·46	4·07	1·11
2·46	1·65	3·05	·83	2·22	1·20	1·88	·88	1·19	2·04	2·94	1·54	3·41	3·10
3·71	1·36	3·63	1·69	3·94	1·75	4·12	1·76	1·70	2·05	4·36	1·41	7·69	3·59
3·24	3·29	2·54	2·05	3·84	1·79	3·93	1·61	3·71	3·34	4·25	2·45	5·17	5·40
1·94	2·02	2·39	2·73	1·25	2·28	1·16	3·46	1·28	5·20	1·31	5·26	3·66	10·59
1·40	1·65	2·27	2·90	1·38	1·63	1·76	1·66	2·27	3·47	3·62	2·77	5·76	3·42
3·79	2·22	5·44	3·11	6·14	3·22	6·76	2·49	5·95	2·27	7·99	1·04	9·95	5·69
4·69	2·30	6·50	5·01	5·15	4·20	5·76	4·28	7·04	4·60	7·66	5·00	8·24	7·33
3·99	·52	4·64	·44	5·11	·57	5·04	·34	8·60	2·00	8·10	1·00	9·82	2·59
36·33	22·89	50·78	32·99	43·68	29·42	44·06	27·35	52·50	42·01	66·70	40·15	84·13	67·29

Division V.—South-Western Counties (*continued*).

Cornwall.													
Helstone.		Penzance.		Tehidy Park, Redruth.		Truro, Royal Institution.		Trevarna, St. Austell.		Bodmin, Castle Street.		Altarnum.	
5 ft. 0 in. 115 ft.		3 ft. 0 in. 94 ft.		0 ft. 6 in. 100 ft.		40 ft. 0 in. 56 ft.		0 ft. 6 in. 300 ft.		2 ft. 4 in. 338 ft.		1 ft. 0 in. 570 ft.	
1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
7·03	4·88	8·99	5·77	9·70	5·88	8·13	5·32	9·41	6·27	9·73	8·06	12·47	10·72
6·25	3·89	6·32	6·62	6·60	4·40	6·98	5·03	8·40	5·73	9·02	4·70	9·59	4·74
3·70	5·50	4·41	4·28	4·15	4·28	3·98	4·05	3·49	4·56	5·25	4·33	6·10	5·68
3·61	·83	3·06	·58	3·25	·50	2·77	·51	3·71	·80	4·36	·64	4·33	·55
2·09	2·01	1·86	2·12	3·35	2·00	2·79	1·49	2·60	2·64	3·01	2·06	3·34	2·83
2·55	1·83	3·30	2·02	4·10	1·75	2·77	1·38	3·35	2·41	3·01	2·22	3·92	2·24
3·39	3·84	2·65	4·23	2·00	4·23	2·69	3·69	3·46	3·86	3·12	3·96	4·00	5·19
2·21	4·04	2·08	5·12	1·75	4·20	1·99	4·81	1·82	5·55	2·18	6·25	2·84	9·12
2·94	3·13	2·53	2·73	2·90	2·30	3·26	2·41	4·43	2·81	4·79	3·99	5·90	4·61
7·15	3·61	7·42	4·25	6·40	3·70	5·67	3·34	6·24	3·30	7·75	4·37	9·80	6·53
4·92	4·31	6·78	3·99	5·40	4·05	5·96	4·05	7·64	4·40	7·42	5·82	9·39	5·89
5·78	1·14	7·81	1·36	6·50	3·50	6·13	1·23	7·87	1·13	9·19	1·26	12·43	1·82
51·62	39·01	57·21	43·07	56·10	40·79	53·12	37·31	62·42	43·46	68·83	47·66	84·11	59·92

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	Division V.—South-Western Counties (*continued*).								Division VI.—West Midland Counties.			
	Somerset.								Gloucester.			
Height of Rain-gauge above	Fulland's School, Taunton.		Ilchester.		Sherborne Reservoir, E. Harptree.		Batheaston Reservoir.		Clifton.		The Firs, Cirencester.	
Ground ...... Sea-level......	1 ft. 4 in.		2 ft. 0 in. 40 ft.		1 ft. 0 in. 338 ft.		2 ft. 0 in. 226 ft.		0 ft. 6 in. 192 ft.		0 ft. 8 in. 352 ft.	
	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	5·59	4·63	4·50	3·93	10·09	7·52	5·00	3·45	6·42	4·44	5·04	3·72
February ...	2·92	1·88	3·14	1·19	5·38	2·02	3·20	·85	4·19	1·42	2·87	1·63
March	2·51	3·66	2·70	3·73	3·40	5·00	2·35	2·95	2·20	3·63	2·54	3·06
April	2·87	·70	3·05	·87	3·44	·66	2·80	·75	2·75	·60	2·37	·82
May	2·16	·88	1·25	1·07	3·28	2·42	2·30	1·95	2·65	2·64	2·09	2·60
June	2·75	1·75	3·74	·99	5·59	1·40	3·82	1·35	3·42	1·17	3·45	2·21
July	3·25	2·00	3·63	3·05	3·23	3·78	3·20	2·97	3·72	4·14	4·65	2·94
August	1·67	3·96	1·67	2·73	2·54	4·04	2·75	2·85	2·18	3·78	3·27	2·61
September ...	1·99	2·22	2·37	2·42	3·58	2·87	2·80	1·90	2·21	2·92	1·61	1·63
October	4·54	2·54	5·29	2·42	6·31	3·81	3·75	2·30	4·12	3·89	3·65	2·36
November ...	4·36	3·32	4·52	3·72	6·86	3·95	4·40	2·20	4·33	2·73	4·82	2·08
December ...	5·52	·35	5·83	·64	8·80	1·16	4·80	·55	4·18	·71	4·04	·97
Totals......	40·13	27·89	41·69	26·76	62·50	38·63	41·17	24·07	42·37	32·07	40·40	26·63

	Division VI.—West Midland Counties (*continued*).								Division VII.—North Midland Counties.			
	Worcester (*continued*).				Warwick.				Leicester.			
Height of Rain-gauge above	Bromsgrove.		Orleton, Tenbury.		Arden House, Henley-in-Arden.		Birmingham.		Wigston.		Thornton Reservoir.	
Ground ...... Sea-level......	4 ft. 0 in. 273 ft.		0 ft. 9 in. 200 ft.		2 ft. 2 in. 400 ft.		0 ft. 8 in. 340 ft.		0 ft. 10 in. 220 ft.		2 ft. 8 in. 420 ft.	
	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	3·99	2·75	5·49	3·29	4·30	1·92	4·75	4·15	3·43	1·61	3·34	2·13
February ...	2·79	·37	4·14	1·02	2·43	1·44	3·41	1·71	2·05	1·74	2·42	·74
March	1·88	2·64	2·30	3·38	1·88	2·17	2·37	2·85	1·90	2·06	1·44	2·16
April	3·20	·91	2·82	·87	2·37	·79	3·92	·78	3·03	·57	2·13	·47
May	1·70	2·24	1·96	2·38	2·06	2·27	2·27	2·39	2·13	2·03	1·43	2·30
June	4·55	2·80	5·29	2·78	7·13	2·06	5·77	4·45	4·68	4·06	4·96	3·24
July	4·27	2·02	3·71	2·63	2·71	3·01	3·56	2·72	5·88	2·34	3·40	2·96
August	3·77	2·68	2·57	3·63	4·21	3·41	3·81	3·07	3·44	2·68	3·09	2·86
September ...	2·10	1·44	2·08	1·34	1·96	1·61	2·65	2·12	2·28	1·45	3·47	1·83
October	4·41	1·94	4·52	2·05	4·30	1·89	4·65	1·68	3·72	2·01	3·43	2·41
November ...	4·47	1·32	4·42	1·59	4·30	·94	3·47	2·30	3·58	1·97	3·83	2·73
December ...	3·94	·54	4·86	·62	3·67	·43	4·51	·56	3·13	·49	3·49	·37
Totals......	41·07	21·65	44·16	25·58	41·32	21·94	45·14	28·78	39·25	23·01	36·43	24·20

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Division VI.—West Midland Counties (*continued*).

Gloucester (*continued*).		Hereford.		Shropshire.				Stafford.		Worcester.			
Quedgeley.		Stretton Rectory, Hereford.		Haughton Hall, Shifnall.		Hengoed, Oswestry.		Barlaston, Stoke.		Northwick Park.		West Malvern.	
0 ft. 10 in. 50 ft.		1 ft. 0 in. 198 ft.		3 ft. 6 in. 353 ft.		6 ft. 0 in. 470 ft.		0 ft. 6 in. 530 ft.		1 ft. 6 in. …………		1 ft. 6 in. 850 ft.	
1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
4·27	2·90	5·17	3·40	4·63	2·37	6·62	4·97	5·72	2·68	4·19	3·75	4·06	3·72
2·48	1·00	3·56	1·32	2·89	·94	4·16	1·56	3·94	1·19	2·68	1·61	3·70	1·38
2·25	3·22	2·00	2·95	2·04	3·20	3·33	3·69	2·85	3·06	2·01	2·26	2·16	2·53
2·71	·84	2·85	1·08	2·96	·78	3·55	2·01	3·18	·90	2·75	1·14	2·02	1·16
1·30	2·53	1·25	1·63	2·06	2·70	2·86	1·74	2·96	2·27	1·90	2·75	3·18	2·33
4·59	2·24	3·41	2·66	4·72	2·61	5·10	1·78	5·29	2·30	3·25	2·47	5·34	1·28
6·51	2·73	4·78	2·76	3·84	2·73	5·06	3·10	5·12	3·32	3·62	3·40	3·15	4·77
2·82	2·33	2·12	2·48	4·21	3·17	3·51	2·83	4·27	2·94	2·92	2·80	1·77	2·97
3·20	1·46	1·89	1·49	3·72	1·43	6·23	2·34	3·74	2·35	1·45	2·02	2·29	2·04
3·33	2·06	3·79	1·60	6·07	2·38	7·09	3·33	5·40	3·60	4·31	1·85	4·09	2·21
5·76	1·65	5·64	1·80	3·21	1·60	6·42	2·61	3·18	2·26	6·86	2·23	5·31	1·52
2·90	·58	5·02	·81	3·71	·85	6·52	1·38	4·38	·72	4·65	·78	4·34	·67
42·12	23·54	41·48	23·98	44·06	24·76	60·45	31·34	50·03	27·59	40·59	27·06	41·41	26·58

Division VII.—North Midland Counties (*continued*).

Leicester (*continued*).		Lincoln.											
Belvoir Castle.		Lincoln.		Market Rasen.		Gainsborough.		Brigg.		Grimsby.		New Holland.	
1 ft. 0 in. 237 ft.		3 ft. 6 in. 26 ft.		3 ft. 6 in. 100 ft.		3 ft. 6 in. 76 ft.		3 ft. 6 in. 16 ft.		15 ft. 0 in. 42 ft.		3 ft. 6 in. 18 ft.	
1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
2·95	2·00	2·39	1·57	2·20	1·69	2·02	1·87	3·00	2·42	2·34	1·48	3·57	1·69
2·10	1·59	2·17	1·34	3·04	1·35	1·78	1·00	1·96	1·27	1·88	1·67	2·13	1·53
2·17	1·64	1·45	1·04	1·69	1·56	1·06	·96	2·04	1·61	1·52	1·66	1·90	1·76
3·38	1·07	3·22	·82	1·96	·93	3·21	·37	2·90	·55	2·81	·55	2·47	·46
1·83	2·25	·93	1·07	1·52	2·37	1·43	·84	·91	1·86	·94	2·20	1·18	1·92
2·92	1·32	2·80	1·54	1·48	1·15	3·14	·60	1·54	1·30	·63	1·05	1·49	2·15
4·23	1·08	5·09	1·72	2·23	2·18	4·40	1·45	3·76	2·71	4·16	2·70	3·41	2·52
2·60	2·61	2·39	2·95	2·70	2·71	5·13	?·95	3·10	2·82	2·05	2·81	2·02	2·30
2·83	1·64	2·90	1·95	2·90	2·00	5·52	·98	3·04	1·80	2·00	2·30	2·70	2·78
3·65	1·94	3·39	2·57	4·97	2·19	5·12	1·86	3·47	1·74	1·94	3·01	3·02	1·85
3·43	2·49	2·83	1·58	3·52	·95	4·48	1·84	2·27	1·45	3·19	1·42	4·32	1·36
3·36	·19	2·59	·16	1·98	·23	2·54	·28	2·33	·38	2·93	·17	3·49	·20
35·45	19·82	32·15	18·31	30·19	19·31	39·83	?13·00	30·32	19·91	26·39	21·02	31·70	20·52

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Division VII.—North Midland Counties (continued).											Div. VIII.—N.-Western Counties.	
	Nottingham.		Derby.								Cheshire.	
Height of Rain-gauge above	Welbeck.		Derby.		Chesterfield.		Comb's Moss.		Chapel-en-le-Frith.		Cholmondelly Castle, Nantwich.	
Ground …… Sea-level……	4 ft. 6 in. 88 ft.		6 ft. 0 in. 180 ft.		3 ft. 6 in. 248 ft.		3 ft. 6 in. 1669 ft.		3 ft. 6 in. 965 ft.		1 ft. 6 in. 42 ft.	
	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January ……	3·05	2·93	3·72	2·04	3·48	3·65	8·02	3·97	7·45	3·75	4·24	2·59
February …	2·24	1·15	2·87	·68	2·61	·81	6·87	1·24	3·36	·73	2·30	·98
March ……	1·91	2·23	1·84	2·15	1·93	2·00	6·27	2·51	4·90	3·23	3·20	3·94
April ………	3·75	·63	2·24	·46	2·83	·55	5·18	1·84	3·81	·77	3·40	1·00
May ………	1·66	2·10	1·63	2·31	3·13	1·82	4·84	3·94	3·80	3·52	2·67	1·93
June ………	3·20	1·53	5·27	2·21	4·02	1·29	10·54	3·86	9·12	3·33	6·59	2·01
July ………	5·60	2·02	4·68	2·14	5·00	1·77	5·36	3·81	5·78	3·10	4·39	3·32
August ……	2·42	2·65	3·34	2·92	2·28	2·60	4·00	4·41	3·67	4·11	3·30	4·12
September …	2·81	1·87	2·93	1·58	4·12	2·35	10·52	4·20	7·85	2·89	5·74	3·05
October ……	4·83	2·42	4·56	2·40	5·22	3·34	9·30	6·53	8·47	4·50	7·49	3·23
November …	3·21	2·77	2·36	2·03	3·43	2·70	6·82	4·88	5·52	3·73	3·85	2·40
December …	3·57	·11	3·78	·26	3·25	·08	5·33	1·83	4·04	1·02	4·51	1·14
Totals……	38·25	22·41	39·22	21·18	41·30	22·96	83·05	43·02	67·77	34·68	51·68	29·71

Division VIII.—North-Western Counties (continued).									Div. IX.—Yorkshire.			
	Lancashire (continued).								York.—West Riding.			
Height of Rain-gauge above	Stonyhurst.		Caton, Lancaster.		Holker, Cartmel.		Coniston.		Broomhall Park, Sheffield.		Redmires, Sheffield.	
Ground …… Sea-level……	1 ft. 0 in. 376 ft.		1 ft. 4 in. 118 ft.		4 ft. 8 in. 155 ft.		1 ft. 0 in. 287 ft.		2 ft. 0 in. 330 ft.		5 ft. 0 in. 1100 ft.	
	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January ……	5·56	6·17	7·09	6·19	8·19	5·71	13·86	11·21	4·24	2·59	5·55	2·71
February …	4·58	·82	4·71	·77	4·68	1·06	9·46	2·11	2·79	1·22	4·11	·87
March ……	4·75	3·40	4·98	3·12	4·21	3·83	8·73	5·15	2·32	2·74	3·25	3·62
April ………	3·68	·82	2·27	·59	1·83	·62	2·58	1·30	3·66	·91	4·82	1·07
May ………	3·20	2·85	2·47	1·62	1·68	2·47	3·97	3·64	2·33	2·29	3·53	3·30
June ………	5·04	4·01	5·45	2·36	4·95	2·45	8·63	4·71	4·56	1·96	6·27	3·23
July ………	4·49	4·81	7·48	4·41	5·95	4·46	6·04	10·31	6·34	1·55	7·16	2·48
August ……	5·57	6·38	5·52	5·26	4·86	5·81	7·61	8·98	2·55	1·85	3·40	3·77
September …	8·85	2·82	7·96	2·54	9·16	2·81	11·43	5·81	3·84	1·95	5·34	2·55
October ……	6·00	8·68	6·47	6·32	6·53	6·52	12·22	12·50	5·42	2·44	6·97	3·42
November …	4·70	3·87	5·05	2·05	5·04	2·98	9·94	5·02	3·78	2·51	4·93	3·83
December …	4·09	2·40	5·24	1·90	4·79	1·94	9·47	5·22	3·98	·39	4·51	1·07
Totals……	60·51	47·03	64·69	37·13	61·87	40·66	103·94	75·96	45·81	22·40	59·84	31·92

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Division VIII.—North-Western Counties (*continued*).

Cheshire (*continued*).		Lancashire.											
Macclesfield.		Manchester.		Waterhouses.		Bolton-le-Moors.		Rufford, Ormskirk.		Audley Place, Blackburn.		South Shore, Blackpool.	
3 ft. 6 in. 539 ft.		2 ft. 7 in. 106 ft.		3 ft. 6 in. 345 ft.		3 ft. 6 in. 283 ft.		0 ft. 8 in. 38 ft.		0 ft. 6 in. 450 ft.		1 ft. 8 in. 29 ft.	
1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
4·73	2·14	4·26	3·14	4·12	3·23	5·35	5·07	4·57	4·31	6·03	6·12	5·45	3·70
3·62	1·06	3·02	·67	3·83	·42	4·60	1·29	3·41	·74	3·17	1·43	2·60	·65
3·20	2·55	2·77	1·79	3·22	2·96	4·15	3·92	3·95	3·30	6·12	3·22	3·20	3·49
3·82	·51	2·98	·51	2·91	·66	3·08	·95	2·77	·72	3·49	·57	1·65	·48
3·34	2·78	2·14	1·91	2·62	2·44	3·03	2·29	2·25	1·99	3·94	3·42	1·40	1·75
5·29	2·72	6·90	2·97	6·54	3·29	6·56	2·47	6·05	1·62	5·68	2·28	5·05	1·93
6·98	3·56	7·66	4·65	7·27	4·91	4·34	7·03	7·08	3·34	4·50	4·68	6·55	2·70
2·18	5·16	2·78	4·20	3·21	4·88	3·79	5·21	3·12	3·48	5·96	6·23	1·95	2·20
3·37	2·72	7·04	2·48	6·57	3·59	8·42	3·18	6·60	2·76	7·08	3·02	7·20	2·20
5·64	5·10	4·40	4·44	4·58	6·04	5·32	6·43	4·77	4·59	6·31	7·18	5·40	4·32
3·09	3·10	3·77	2·28	4·46	3·25	4·80	3·47	3·81	2·04	5·72	4·14	3·18	1·65
3·95	·99	2·97	·78	2·16	·97	4·15	1·38	3·88	1·42	5·02	1·81	3·72	1·20
49·21	32·39	50·69	29·82	51·49	36·64	57·59	42·69	52·26	30·31	63·02	44·10	47·35	26·27

Division IX.—Yorkshire (*continued*).

York.—West Riding (*continued*).													
Tickhill.		Penistone.		Saddleworth.		Ackworth, Pontefract.		Goole.		Well Head, Halifax.		Ovenden Moor, Halifax.	
1 ft. 0 in. 61 ft.		3 ft. 6 in. 717 ft.		5 ft. 0 in. 640 ft.		1 ft. 6 in. 135 ft.		3 ft. 4 in.		1 ft. 0 in. 486 ft.		0 ft. 10 in. 1375 ft.	
1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
2·89	1·98	5·21	2·87	4·37	5·08	2·48	1·58	2·30	1·52	4·23	3·93	5·90	4·50
2·10	1·01	3·58	1·10	4·88	·56	2·18	·70	2·93	·75	3·57	·80	4·80	·90
1·78	2·07	2·48	2·78	3·34	4·04	1·86	2·22	2·53	2·10	2·57	2·86	3·40	2·60
3·14	·76	3·82	·15	2·31	1·34	3·65	·85	3·00	1·08	3·60	·31	4·00	·60
1·12	1·86	2·23	2·76	3·48	2·47	1·02	2·36	1·45	2·06	2·05	2·11	2·40	2·80
3·91	1·04	4·29	2·30	5·63	3·17	4·41	·58	4·18	1·70	5·01	1·24	6·60	1·60
6·08	2·01	8·31	1·44	6·30	2·22	8·01	3·04	4·88	2·81	3·70	2·84	4·30	3·70
1·68	2·01	2·21	2·22	4·39	4·57	2·64	2·50	2·11	2·32	4·00	2·47	5·90	4·40
3·71	1·68	4·97	2·63	6·68	3·38	3·85	2·13	5·12	2·14	5·05	2·22	7·00	2·70
4·11	1·79	6·93	4·19	6·75	5·62	4·41	1·49	4·22	1·88	4·07	3·75	5·60	6·90
2·85	1·98	5·44	2·73	5·75	3·15	3·31	1·44	3·28	1·35	5·96	2·31	6·40	3·60
3·25	·14	4·95	·61	2·92	1·00	3·25	·18	2·46	·31	3·40	·72	4·40	2·10
36·62	18·33	54·42	25·78	56·80	36·60	41·07	19·07	38·46	20·02	47·21	25·56	60·70	36·40

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Division IX.—Yorkshire (continued).

	York.—West Riding (continued).								York.—East Riding.			
Height of Rain-gauge above	Eccup, Leeds.		York.		Harrogate.		Arncliffe.		Beverley Road, Hull.		Warter, Pocklington.	
Ground ...... Sea-level......	0 ft. 9 in. 340 ft.		0 ft. 6 in. 50 ft.		0 ft. 6 in. 380 ft.		2 ft. 9 in. 750 ft.		3 ft. 10 in. 11 ft.		1 ft. 10 in. 230 ft.	
	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	3·72	2·57	2·89	2·12	4·50	3·18	9·18	8·90	3·40	1·72	3·78	2·05
February ...	3·24	1·19	2·50	1·28	3·15	1·69	7·91	1·27	2·66	1·81	3·22	1·52
March	2·28	2·86	2·17	2·16	2·31	3·39	6·39	3·85	2·55	2·45	2·74	2·92
April	3·35	·64	2·81	·80	3·51	·95	4·44	·69	2·88	·78	2·96	1·18
May	1·44	2·82	1·02	2·25	1·64	2·68	3·94	2·55	1·68	2·28	2·02	2·69
June	4·74	1·33	5·84	·96	4·70	1·90	6·05	2·53	1·83	1·36	3·36	1·47
July	5·31	3·01	4·30	1·74	5·90	2·65	3·42	5·47	4·83	3·08	5·20	3·15
August	3·18	2·65	2·81	2·15	4·48	2·76	4·58	6·68	2·24	2·81	3·63	2·82
September ...	3·95	2·08	3·63	1·84	5·18	2·18	9·59	4·49	3·50	1·98	5·56	2·48
October	5·41	2·18	3·94	1·67	5·10	2·39	7·28	9·10	3·19	2·04	4·58	2·27
November ...	4·31	2·11	4·30	1·45	5·23	2·22	10·21	4·66	4·46	1·48	5·46	1·27
December ...	3·94	·50	3·76	·38	4·18	·70	6·01	3·57	3·28	·30	4·24	·52
Totals......	44·87	23·94	39·97	18·80	49·88	26·69	79·00	53·76	36·50	22·09	46·75	24·34

Division X.—Northern Counties (continued).

	Northumberland.								Cumberland.			
Height of Rain-gauge above	Bywell.		North Shields.		Haltwhistle.		Lilburn Tower.		Bootle.		Seathwaite.	
Ground ...... Sea-level......	0 ft. 6 in. 87 ft.		1 ft. 0 in. 126 ft.		0 ft. 9 in. 380 ft.		6 ft. 0 in. 300 ft.		1 ft. 0 in. 80 ft.		1 ft. 0 in. 422 ft.	
	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	4·30	2·14	2·78	1·02	3·75	6·34	2·88	1·88	8·55	5·18	32·14	28·64
February ...	3·72	1·65	2·39	1·91	2·60	·61	2·62	2·12	6·26	1·43	17·53	3·05
March	4·60	2·18	3·45	1·86	2·86	1·86	2·92	1·73	4·38	4·33	11·23	7·30
April	3·80	1·01	1·94	1·05	2·79	·68	3·85	·48	1·38	·55	5·08	1·76
May	1·73	2·86	1·96	3·03	2·82	1·95	2·52	1·50	2·69	1·39	9·54	5·58
June	2·57	1·62	2·95	1·43	3·52	1·40	1·50	1·04	6·90	2·64	12·30	7·78
July	4·60	2·22	2.39	2·27	4·25	1·81	5·63	1·90	4·83	5·57	5·90	16·96
August	4·18	2·49	3·71	3·47	4·54	4·61	3·42	3·73	4·08	4·10	9·34	18·73
September ...	5·20	2·19	4·79	2·16	4·87	2·56	5·98	2·47	7·98	2·23	20·85	13·70
October	5·83	2·85	5·96	2·24	5·47	4·02	5·98	3·22	8·11	5·91	19·13	21·23
November ...	5·13	2·07	4·11	1·30	4·77	2·44	4·43	2·47	5·19	2·89	18·64	10·06
December ...	5·50	·72	4·46	·29	4·05	1·89	4·86	1·34	6·79	2·32	20·37	11·74
Totals	51·16	24·00	40·89	22·03	46·29	30·17	46·59	23·88	67·14	38·54	182·05	146·53

ENGLAND.

Division IX.—Yorkshire (*continued*).										Division X.—Northern Counties.			
York.—North Riding.										Durham.			
Malton.		Beadlam Grange.		Scarborough.		Northallerton.		Middlesborough.		Ushaw, Durham.		Wolsingham.	
1 ft. 0 in. 75 ft.		0 ft. 6 in. 192 ft.		1 ft. 0 in. 102 ft.		1 ft. 3 in. 133 ft.		1 ft. 6 in. 21 ft.		0 ft. 10 in. 600 ft.		1 ft. 0 in. 464 ft.	
1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
3·14	1·81	3·59	1·73	2·99	1·29	2·02	1·56	1·47	·92	3·06	1·80	4·78	3·28
2·25	1·36	2·64	1·91	1·98	1·91	2·44	1·03	2·00	1·16	3·29	1·61	3·77	2·01
2·78	2·04	2·79	2·91	2·82	1·60	2·62	2·69	2·38	1·21	3·20	2·38	4·48	3·10
2·66	·96	3·00	1·65	2·22	1·00	2·93	1·26	2·52	1·21	2·87	1·09	3·85	·99
1·47	2·26	1·95	1·90	2·33	1·81	2·11	2·29	2·62	1·89	1·97	2·63	2·23	2·44
4·14	1·37	4·40	1·94	2·40	1·39	4·77	·98	3·24	1·03	2·55	2·14	2·74	1·32
4·66	2·18	3·98	5·14	3·78	2·24	4·40	2·44	3·15	1·94	4·52	2·26	5·03	2·26
2·82	2·27	3·39	4·80	2·48	1·76	3·62	1·73	3·53	2·08	3·21	3·03	3·64	2·77
5·18	1·66	5·04	2·46	6·02	2·57	3·75	1·35	5·26	1·02	4·65	1·61	4·65	1·92
3·92	2·74	5·24	2·09	3·98	2·16	4·10	1·98	3·43	1·84	5·51	1·96	7·02	2·29
4·88	1·58	5·96	1·78	5·56	1·41	4·42	2·28	2·80	1·35	4·67	1·34	6·27	1·91
3·89	·48	4·02	·29	2·74	·58	3·35	·33	2·30	·21	4·43	·37	5·34	·69
41·79	20·71	46·00	28·60	39·30	19·72	40·53	19·92	34·70	15·86	43·93	22·22	53·80	24·98

Division X.—Northern Counties (*continued*).													
Cumberland (*continued*).						Westmoreland.							
Whinfell Hall, Cockermouth.		Post Office, Keswick.		Scaleby Hall.		Kendal.		Kirkby Stephen.		Appleby.		Great Strickland, Penrith.	
2 ft. 0 in. 265 ft.		1 ft. 0 in. 270 ft.		1 ft. 1 in. 112 feet.		1 ft. 6 in. 146 ft.		1 ft. 0 in. 574 ft.		1 ft. 0 in. 442 ft.		1 ft. 0 in. 650 ft.	
1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
9·95	10·68	11·62	13·96	4·95	5·73	9·87	9·44	7·10	9·08	5·98	8·93	8·86	8·72
5·23	·72	5·37	·93	2·90	·53	5·93	·65	4·97	·64	4·38	1·38	9·47	1·15
4·55	3·51	3·82	3·79	2·71	2·07	5·61	3·30	3·92	2·29	2·62	2·01	3·32	2·14
1·98	·40	2·54	·66	1·36	·36	2·19	·51	3·21	·69	1·14	·67	·93	·26
3·76	2·16	2·74	2·05	2·67	2·30	2·73	2·52	2·46	1·54	2·44	·92	1·56	1·42
6·03	3·09	4·99	2·27	3·37	1·38	4·65	2·69	5·05	1·59	3·26	1·36	2·84	1·30
3·78	7·07	3·80	7·15	4·63	7·09	4·80	7·30	3·97	3·39	3·03	2·59	4·09	3·39
4·01	6·10	4·25	6·15	2·37	6·01	4·64	5·90	4·76	3·24	4·45	3·26	3·92	3·58
8·40	3·12	8·89	3·44	4·68	3·53	8·18	2·94	4·92	2·23	4·35	1·42	5·57	2·13
10·06	7·35	9·74	6·12	5·34	4·64	7·57	8·36	7·23	3·77	6·23	2·90	7·06	3·72
7·16	3·26	10·17	3·09	2·91	1·87	6·64	3·33	5·74	2·30	3·79	2·16	5·92	2·03
7·59	2·78	8·41	3·65	4·13	1·11	6·37	2·43	5·79	1·50	4·25	1·43	5·62	1·64
72·50	50·24	76·34	53·26	42·02	36·62	69·18	49·37	59·12	32·26	45·92	29·03	59·16	31·48

WALES.

Division XI.—Monmouth, Wales, and the Islands.

	Monmouth.				Glamorgan.				Carmarthen.		Pembroke.	
	Llanfrechfa, Newport.		Abergavenny.		Swansea.		Pentyrch, Cardiff.		Carmarthen Gaol.		Haverford-west.	
Height of Rain-gauge above Ground …… Sea-level……	4 ft. 0 in. 326 ft.		1 ft. 0 in. 220 ft.		14 ft. 9 in. 40 ft.		1 ft. 1 in. 100 ft.		0 ft. 6 in. 92 ft.		1 ft. 0 in. 94 ft.	
	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January ……	9·85	9·77	7·01	6·15	7·76	5·72	8·81	6·63	9·75	8·39	8·90	7·88
February …	5·29	1·81	5·42	2·22	4·01	·85	5·07	1·86	7·34	2·54	6·62	3·76
March ……	5·34	6·03	3·41	4·14	3·47	3·33	4·10	4·78	6·26	3·57	5·37	4·17
April ………	2·20	·62	2·84	·63	1·60	·53	2·08	·49	2·69	·72	2·45	·96
May ………	2·06	2·53	1·19	2·13	1·31	2·84	2·87	3·10	2·23	2·80	2·30	3·25
June ………	4·18	3·30	3·50	3·04	4·87	1·06	5·52	2·73	7·43	1·99	5·38	2·11
July ………	3·68	4·18	4·34	2·82	3·42	3·00	5·92	5·01	2·99	4·39	4·61	4·23
August ……	2·68	4·03	2·09	3·67	2·65	4·38	3·50	5·33	3·45	6·72	2·02	6·05
September …	3·29	3·06	2·25	1·89	3·81	2·72	5·14	3·34	5·66	3·66	5·50	3·73
October ……	6·90	4·00	4·91	1·99	6·16	3·56	5·97	5·62	7·70	4·56	7·93	4·43
November …	9·67	1·01	7·58	2·41	5·51	1·73	6·00	2·83	9·67	2·46	8·71	3·44
December …	7·13	1·09	7·66	·70	6·12	1·52	7·75	2·62	9·69	2·24	9·99	1·66
Totals ……	62·27	41·43	52·20	31·79	50·69	31·24	62·73	44·34	74·86	44·04	69·78	45·67

Division XI.—Monmouth, Wales, and the Islands.

	Merioneth.				Flint.				Carnarvon.			
	Dolgelly, Brithdir.		Bala.		Maes-y-dre.		Hawarden.		Beddgelert.		Cocksidia, Carnarvon.	
Height of Rain-gauge above Ground …… Sea-level……	1 ft. 6 in. 500 ft.		1 ft. 0 in. 544 ft.		5 ft. 0 in. 400 ft.		0 ft. 6 in. 270 ft.		3 ft. 0 in. 264 ft.		1 ft. 1 in. 120 ft.	
	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January ……	10·78	13·93	8·81	8·87	2·53	1·95	3·24	2·16	22·53	21·46	6·58	6·26
February …	8·35	1·57	6·06	1·38	2·04	·66	2·65	·89	12·47	3·50	4·52	1·14
March ……	7·13	4·54	4·67	3·58	1·96	2·34	3·64	3·44	13·51	8·59	3·74	2·94
April ………	1·57	2·04	3·32	1·32	2·07	·67	3·40	·92	5·45	3·73	1·94	1·22
May ………	4·63	2·90	2·92	2·36	2·03	1·49	1·93	1·90	5·96	5·37	2·32	1·66
June ………	7·93	3·33	4·70	1·54	3·68	1·18	4·65	1·21	12·21	6·01	5·29	1·10
July ………	6·08	5·75	5·02	4·61	4·00	1·47	6·76	1·48	6·49	10·56	4·61	3·01
August ……	5·18	7·50	3·43	4·35	2·04	2·63	2·40	3·27	6·84	11·86	3·13	4·49
September …	11·82	4·49	8·29	3·51	5·20	2·74	4·88	4·34	14·77	10·09	6·52	3·00
October ……	9·42	9·84	8·88	6·11	5·08	2·53	7·02	2·56	16·95	12·12	10·28	5·54
November …	14·24	4·21	11·65	3·16	2·88	1·73	4·01	2·01	17·06	8·36	6·12	1·96
December …	13·26	2·69	7·43	1·98	3·61	·73	3·90	·89	15·97	6·29	6·21	2·01
Totals ……	100·39	62·79	75·18	42·77	37·12	20·12	48·48	25·07	150·21	107·94	61·26	34·33

WALES.

Division XI.—Monmouth, Wales, and the Islands.

Pembroke (*continued*).		Brecknock.		Montgomery.		Cardigan.				Radnor.			
Castle Malgwyn.		Brecknock.		Carno.		Lampeter.		Goginan.		Rhayader.		Heyhope Rectory.	
1 ft. 2 in. 50 ft.		2 ft. 0 in. 437 ft.		1 ft. 0 in. 550 ft.		4 ft. 6 in. 420 ft.		2 ft. 6 in. 290 ft.		2 ft. 0 in. 880 ft.		1 ft. 0 in. 690 ft.	
1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
4·96	8·22	10·30	9·74	7·50	6·20	No observations during this period.	5·20	5·81	4·80	7·51	5·64	7·79	6·53
6·21	2·06	6·57	1·38	5·30	7·30		1·58	3·51	1·34	5·85	2·26	5·76	1·43
6·43	3·05	4·62	3·26	3·60	4·00		2·99	3·97	3·33	3·51	3·30	3·77	4·36
2·39	·49	3·45	2·57	3·30	1·80		1·01	3·28	1·45	3·63	1·87	3·83	1·86
1·65	2·40	1·72	1·72	3·70	3·20		2·19	2·20	3·05	3·28	3·41	2·55	2·35
4·83	1·32	4·53	2·11	5·20	1·60		·63	6·18	1·64	5·72	1·95	4·33	2·47
4·63	3·87	6·07	1·92	5·30	3·10		2·79	4·14	4·53	5·43	3·78	5·99	3·55
4·42	5·53	3·69	3·68	4·00	4·00		3·91	2·63	5·46	4·34	5·77	3·08	3·40
6·25	3·37	4·38	2·26	5·80	4·30		2·14	7·08	5·14	5·75	2·71	4·25	2·15
8·62	2·45	6·80	2·75	6·70	4·70	9·47	3·74	7·66	6·52	8·60	3·34	6·75	3·75
8·57	2·12	13·06	3·52	8·50	3·20	8·03	2·47	8·06	2·46	10·48	3·30	8·63	2·80
9·30	1·78	10·34	1·51	8·10	4·20		·87	5·72	1·60	9·66	1·24	7·87	1·17
68·26	36·66	75·53	36·42	67·00	47·60		29·52	60·24	41·32	73·76	38·57	64·60	35·82

Division XI.—Monmouth, Wales, and the Islands.

Carnarvon (*continued*).				Isle of Man.				Guernsey.		Sark.		Jersey.	
Llanfair-fechan.		Llandudno.		Douglas.		Kirk Michael.		Guernsey.		Sark.		Millbrook.	
0 ft. 8 in. 150 ft.		0 ft. 6 in. 98 ft.		1 ft. 1 in. 78 ft.		1 ft. 0 in. 100 ft.		12 ft. 0 in. 204 ft.		1 ft. 0 in. 340 ft.		1 ft. 0 in. 50 ft.	
1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
6·49	8·25	3·35	5·81	8·72	7·87	6·83	5·82	6·11	6·63	4·95	4·86	4·42	4·07
5·18	1·07	3·04	1·23	4·98	1·80	6·72	2·86	2·77	3·31	2·37	3·65	1·27	3·40
3·33	2·96	2·19	2·09	3·61	3·68	3·27	3·94	4·41	3·85	3·05	3·46	2·49	4·56
2·48	1·49	2·17	1·04	2·21	·42	2·18	·23	2·40	·47	1·94	·53	1·74	·49
3·17	1·65	2·02	1·18	1·97	1·65	1·76	1·18	4·05	1·64	3·71	1·67	3·53	1·00
5·28	1·64	5·20	·66	6·14	1·11	5·16	·19	3·13	1·62	2·48	1·72	2·03	2·40
5·95	2·12	3·46	2·28	4·12	2·75	4·22	2·28	4·53	3·34	4·14	2·35	4·58	2·96
2·24	3·68	2·15	2·44	5·61	2·91	3·69	2·08	2·19	5·09	1·13	4·62	1·45	4·43
7·27	3·53	6·83	2·65	6·37	2·49	4·90	1·69	2·14	2·34	2·05	2·09	2·52	2·74
10·42	3·92	8·16	3·98	4·98	4·53	6·36	2·45	11·04	2·51	7·71	3·29	7·39	2·95
7·13	2·05	5·22	1·68	6·79	3·04	5·90	1·89	7·40	5·87	7·56	3·42	7·90	2·66
7·10	1·98	4·23	1·44	7·44	1·52	8·33	1·33	6·79	1·05	6·08	1·59	7·17	·99
66·03	34·34	48·02	26·48	62·94	33·77	59·32	25·94	56·96	37·72	47·17	33·25	46·49	32·65

SCOTLAND.

Division XII.—Southern Counties.

	Wigtown.		Kirkcudbright.						Dumfries.			
	Balfern.		Little Ross.		Carsphairn.		Cargen.		Drumlanrig.		Wanlock-head.	
Height of Rain-gauge above Ground ...... Sea-level......	0 ft. 11. in. 75 ft.		3 ft. 3 in. 130 ft.		3 ft. 10 in. 574 ft.		0 ft. 4 in. 80 ft.		.... 191 ft.		0 ft. 4 in. 1330 ft.	
	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	9·33	5·48	4·43	2·90	13·14	11·60	10·02	8·70	11·00	10·10	16·75	12·52
February ...	5·36	·97	2·55	·51	8·73	1·98	6·76	1·05	7·40	1·20	9·36	1·85
March	4·20	3·49	2·72	2·76	5·40	3·80	3·96	3·59	3·90	3·70	6·80	5·38
April	·78	·51	·49	·20	1·39	·53	1·13	·10	2·00	·15	2·35	·23
May	2·58	1·90	2·19	1·93	3·62	2·42	3·54	2·22	3·30	2·30	2·96	3·73
June	5·28	1·59	4·39	1·53	7·11	2·17	5·91	1·42	8·00	1·60	9·25	3·64
July	3·70	5·79	4·42	2·81	3·94	6·89	4·31	5·46	4·10	7·70	3·78	12·95
August	5·38	4·36	3·39	2·43	5·85	5·87	3·27	6·49	4·30	5·90	6·12	6·74
September ...	5·93	3·32	4·07	2·14	8·90	5·58	5·62	3·76	5·70	4·30	8·41	6·39
October	4·96	5·46	3·57	4·36	5·33	7·79	5·12	6·08	4·00	8·10	5·82	7·83
November ...	5·46	1·82	2·64	1·59	9·47	4·44	5·30	2·44	8·40	3·60	10·56	4·80
December ...	9·26	1·65	5·83	·67	13·80	3·95	8·56	2·21	9·50	3·50	15·54	5·86
Totals	62·22	36·34	40·69	23·83	86·68	57·02	63·50	43·52	71·60	52·15	97·70	71·92

Division XIV.—South-Western Counties.

	Lanark.						Ayr.				Renfrew.	
	Newmains, Douglas.		Auchinraith, Hamilton.		Glasgow Observatory.		Hole House, Patna.		Mansfield, Largs.		Newton Mearns.	
Height of Rain-gauge above Ground ...... Sea-level......	0 ft. 4 in. 783 ft.		4 ft. 9 in. 150 ft.		0 ft. 1 in. 180 ft.		1 ft. 0 in. 446 ft.		0 ft. 6 in. 30 ft.		1 ft. 0 in. 350 ft.	
	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	9·23	8·47	4·65	4·50	5·95	6·67	8·54	6·07	8·00	7·10	8·56	9·26
February ...	3·45	1·13	2·45	1·15	3·09	2·02	3·49	·82	6·00	1·10	3·65	1·25
March	2·85	3·37	1·74	2·10	2·61	2·52	2·24	2·87	4·10	2·00	3·71	3·14
April	1·11	·59	·62	·08	·92	·26	·99	·26	1·40	·30	1·32	·30
May	3·57	3·45	2·78	2·35	3·68	3·47	3·28	2·30	2·80	2·60	3·43	2·94
June	5·27	1·78	6·68	1·30	9·04	2·54	5·79	1·64	7·50	2·30	6·55	3·02
July	3·72	5·42	6·26	4·35	6·52	5·33	3·60	4·98	4·50	6·10	4·80	5·49
August	3·93	5·69	3·50	4·02	5·19	4·56	4·21	5·47	3·40	5·20	3·86	5·16
September ...	8·51	5·70	6·60	4·06	9·80	5·16	8·17	6·08	7·90	5·00	8·76	5·03
October	4·78	8·04	2·60	4·76	3·69	6·35	4·56	6·76	4·50	5·90	4·71	8·01
November ...	6·69	2·80	4·04	1·35	5·11	2·39	5·75	2·66	8·00	4·00	7·47	3·25
December ...	7·81	3·81	4·02	2·05	6·00	2·25	5·08	2·95	7·20	3·00	8·14	4·90
Totals	60·92	50·25	45·94	32·07	61·60	43·52	55·70	42·86	65·30	44·60	64·96	51·75

SCOTLAND.

Division XIII.—South-Eastern Counties.

Roxburgh.		Selkirk.		Peebles.		Berwick.		Haddington.		Edinburgh.			
Silverbut Hall, Hawick.		Galashiels.		North Esk Reservoir, Penicuick.		Thirlestane.		East Linton.		Glencorse.		Charlotte Sq., Edinburgh.	
4 ft. 0 in. 512 ft.		0 ft. 6 in. 416 ft.		0 ft. 6 in. 1150 ft.		0 ft. 3 in. 558 ft.		0 ft. 3 in. 90 ft.		0 ft. 6 in. 787 ft.		0 ft. 6 in. 230 ft.	
1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
3·97	5·62	4·25	4·72	5·20	4·60	4·20	3·10	4·21	1·44	5·50	4·85	3·63	2·32
3·32	1·18	3·99	1·72	2·35	1·45	4·00	1·90	2·34	1·98	2·60	1·40	2·02	1·38
2·56	1·61	2·94	1·64	3·20	2·15	2·80	1·40	3·32	1·72	4·60	1·50	3·30	1·60
3·03	·60	3·16	·82	1·95	·20	2·90	·30	2·68	·85	3·35	·40	1·70	·21
3·66	1·91	2·97	2·15	4·15	2·85	2·70	1·70	3·20	2·40	5·20	2·50	3·46	2·70
2·78	1·52	3·13	·63	3·55	1·30	2·50	·40	3·10	2·18	3·35	1·05	3·13	1·21
5·62	4·06	3·99	4·17	2·50	3·75	3·10	4·00	2·70	5·43	3·85	3·85	3·58	2·80
4·22	4·09	4·23	3·45	4·15	4·50	3·70	2·70	3·72	3·27	3·75	4·50	3·28	4·53
3·84	2·56	4·49	2·96	6·05	4·45	5·10	1·60	5·15	2·46	5·30	3·25	5·80	4·46
3·86	3·91	4·59	4·07	5·15	5·70	6·30	4·30	3·53	3·51	5·55	6·10	3·38	3·07
4·92	2·37	6·54	2·82	7·10	4·35	6·60	2·30	3·82	2·51	5·75	4·20	3·60	2·47
4·29	1·48	4·74	1·53	2·95	2·55	4·65	1·60	2·66	1·37	2·90	2·90	2·08	1·44
46·07	30·91	49·02	30·68	48·30	37·85	48·55	25·30	40·43	29·12	51·70	36·50	38·96	28·19

Div. XIV. (*continued*).		Division XV.—West Midland Counties.											
Renfrew (*continued*).		Dumbarton.				Stirling.		Bute.		Argyll.			
Glenbrae, Greenock.		Ballock Castle.		Arddarock, Loch Long.		Polmaise Garden.		Pladda.		Castle Toward.		Callton Môr.	
0 ft. 9 in. 574 ft.		0 ft. 4 in. 91 ft.		0 ft. 10 in. 80 ft.		0 ft. 9 in. 12 ft.		3 ft. 3 in. 55 ft.		4 ft. 0 in. 65 ft.		4 ft. 0 in. 65 ft.	
1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
11·60	11·90	8·65	8·74	12·34	14·05	5·00	7·50	5·43	7·53	8·21	7·77	9·15	7·46
7·50	1·70	5·12	1·52	10·59	1·36	3·50	1·30	3·58	·29	5·35	1·77	5·89	·61
5·10	3·00	5·00	2·33	6·58	3·57	2·60	2·00	3·61	1·90	4·35	1·79	4·55	2·70
2·00	·50	1·67	·32	3·51	·94	2·40	·30	·64	·41	1·82	·39	1·62	·87
3·50	4·10	3·15	3·62	3·94	4·19	3·80	2·40	2·46	2·73	3·79	3·18	3·01	3·01
8·20	3·30	7·60	2·47	9·18	4·36	6·20	1·70	7·12	1·96	8·67	2·39	8·09	2·43
4·80	6·20	7·39	6·34	6·26	8·69	3·20	4·70	4·21	3·68	4·83	5·36	3·65	5·77
5·00	7·20	4·82	5·57	8·55	7·07	4·80	4·20	4·53	4·01	6·33	4·89	5·15	6·18
11·40	8·50	9·56	5·87	10·82	5·77	5·40	4·10	6·41	3·39	8·39	5·34	9·27	8·56
6·00	9·00	4·48	8·85	9·53	11·48	3·00	5·50	4·58	9·37	5·71	8·19	6·29	10·36
10·80	5·70	8·60	4·75	12·89	6·92	5·80	1·70	5·30	4·51	8·39	5·19	7·49	4·21
9·10	6·80	7·80	4·61	12·34	8·06	5·70	3·10	5·27	2·12	6·32	3·39	5·67	4·99
85·00	67·90	73·84	54·99	106·53	76·46	51·40	38·50	53·14	41·90	72·16	49·65	69·83	57·15

SCOTLAND.

Division XV.—West Midland Counties (*continued*).

Argyll (*continued*).

Height of Rain-gauge above Ground ...... Sea-level......	Inverary Castle. 0 ft. 2 in. 30 ft.		Airds, Appin. 0 ft. 5 in. 15 ft.		Corran, Loch Eil. 0 ft. 4 in. 14 ft.		Ardnamurchan. 3 ft. 6 in. 82 ft.		Devaar, Campbeltown. 3 ft. 4 in. 75 ft.		Skipness Castle. 1 ft. 4 in. 20 ft.	
	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	7·00	8·00	9·10	7·40	11·80	13·60	6·82	7·32	9·56	7·20	5·70	6·30
February ...	6·00	2·00	5·10	·60	8·15	·60	4·64	·38	4·74	1·33	4·20	1·30
March	4·00	1·00	3·80	2·70	2·35	3·20	2·39	1·99	3·53	2·07	3·50	2·30
April	1·00	1·00	2·40	1·30	3·95	·95	2·02	·61	1·25	·54	3·70	2·50
May	4·00	4·00	2·50	2·60	3·65	2·70	2·70	2·29	3·38	2·26	3·50	·70
June	11·00	4·00	10·10	3·90	7·30	5·50	5·49	3·08	5·34	1·67	6·70	2·50
July	4·00	8·50	4·00	7·20	4·05	9·40	3·37	3·99	3·94	4·57	3·50	5·20
August	6·00	8·00	6·70	5·50	7·80	7·10	3·12	4·72	3·52	4·57	3·70	6·20
September ...	5·50	6·50	7·60	5·00	9·25	6·45	6·42	3·92	5·25	3·14	8·60	5·60
October	6·00	11·00	6·10	7·60	8·15	8·50	7·74	8·30	3·62	8·59	5·30	7·40
November ...	9·00	7·00	6·50	5·40	9·65	6·90	6·43	5·44	6·29	4·41	6·10	4·10
December ...	8·00	11·00	4·30	6·30	5·90	12·25	4·04	5·30	8·02	2·23	5·40	3·70
Totals	71·50	72·00	68·20	55·50	82·00	77·15	55·18	47·34	58·44	42·58	59·90	47·80

Division XVI.—East Midland Counties (*continued*).

Perth (*continued*).

Height of Rain-gauge above Ground ...... Sea-level......	Deanston. 1 ft. 0 in. 130 ft.		Loch Katrine. 0 ft. 6 in. 830 ft.		Auchterarder House. 2 ft. 3 in. 162 ft.		Stronvar, Loch Earn Head. 0 ft. 4 in. 460 ft.		Trinity Gask. 0 ft. 1 in. 133 ft.		Scone Palace. 2 ft. 6 in. 80 ft.	
	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	5·52	6·67	11·00	13·40	4·85	5·93	12·25	11·10	4·90	5·35	4·10	3·88
February ...	4·12	1·08	11·60	1·40	5·84	1·25	13·00	1·25	4·80	2·65	5·64	1·00
March	3·74	1·45	5·60	3·10	2·05	1·40	4·00	2·95	2·90	1·55	2·61	1·20
April	1·35	·38	2·80	1·00	1·08	·20	2·90	1·80	·98	·20	·90	·20
May	2·99	3·17	3·30	4·40	3·08	2·88	3·82	3·90	4·80	3·08	3·38	2·88
June	6·88	2·06	11·20	4·20	3·74	·63	7·00	3·20	5·20	1·20	3·68	1·17
July	3·65	6·84	7·20	9·00	2·50	3·73	5·85	7·70	2·96	4·54	3·00	3·25
August	6·26	4·82	10·10	7·30	2·35	3·33	6·85	5·50	3·00	4·26	4·60	1·65
September ...	7·11	4·02	9·90	5·20	4·65	2·15	9·10	4·25	5·16	3·55	5·40	3·52
October	3·43	6·26	8·30	9·60	3·95	3·48	7·30	8·35	3·45	3·80	3·25	3·40
November ...	7·70	2·91	13·10	5·50	5·64	} 2·16	12·90	5·80	5·44	2·03	4·90	1·40
December ...	5·48	3·69	13·00	10·10	5·18		10·80	9·15	6·10	2·23	6·20	1·60
Totals	58·23	43·35	107·10	74·20	44·91	27·14	95·77	64·95	49·69	34·44	47·66	25·15

SCOTLAND.

Div. XV.—West Midland Counties (continued).								Division XVI.—East Midland Counties.					
Argyll (continued).								Kinross.		Fife.		Perth.	
Rhinns of Islay.		Eallabus, Islay.		Lismore.		Hynish.		Loch Leven Sluice.		Nookton.		Kippenross.	
3 ft. 0 in. 74 ft.		1 ft. 0 in. 71 ft.		3 ft. 4 in. 37 ft.		....		0 ft. 10 in. 360 ft.		0 ft. 6 in. 80 ft.		0 ft. 4 in. 150 ft.	
1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
5·71	4·56	7·47	6·13	6·85	7·29	4·57	12·83	4·80	4·30	4·15	3·69	4·75	6·45
2·86	·79	4·68	·83	6·29	·54	8·63	·71	5·00	1·20	4·06	1·13	3·90	1·00
1·76	2·35	3·05	2·28	2·07	1·28	6·02	3·96	3·30	1·90	2·61	1·70	2·85	1·40
2·05	·88	1·12	·75	1·33	·47	4·07	·65	1·30	·10	1·75	·29	1·20	·00
2·06	2·57	2·27	1·87	2·06	2·32	5·08	3·01	3·50	3·10	2·92	2·77	2·70	2·30
5·32	1·73	4·97	2·16	6·50	2·33	6·39	3·41	4·40	1·40	3·63	1·39	5·50	1·75
1·72	3·77	1·47	4·96	3·61	5·59	3·09	8·10	2·60	5·00	3·37	3·62	3·50	4·15
2·82	4·03	4·13	5·14	4·35	4·17	3·69	6·03	5·80	4·00	5·98	3·43	3·80	4·00
5·22	2·93	7·70	4·98	3·44	2·73	3·20	4·26	3·30	3·60	3·92	3·42	5·80	3·50
5·56	7·85	6·30	7·96	5·09	5·73	8·53	7·00	3·50	4·30	3·58	3·73	2·55	6·00
6·06	2·53	7·75	3·24	3·66	4·45	9·32	5·50	6·00	3·10	4·44	1·97	7·60	3·00
4·23	2·19	4·77	3·76	2·75	4·31	4·49	7·81	4·80	2·00	3·04	1·56	6·80	3·20
45·37	36·18	55·68	44·06	48·00	41·21	67·08	63·27	48·30	34·00	43·45	28·70	50·95	36·75

Division XVI.—East Midland Counties (continued).								Division XVII.—North-Eastern Counties.					
Perth (continued).		Forfar.						Kincardine.		Aberdeen.			
Strath-tay, Logierait.		Dundee Necropolis.		Arbroath.		Montrose, Bridge Street.		The Burn, Brechin.		Braemar.		Aberdeen, Rose Street.	
1 ft. 0 in. 313 ft.		0 ft. 5 in. 167 ft.		2 ft. 0 in. 60 ft.		0 ft. 3 in. 25 ft.		0 ft. 4 in. 235 ft.		0 ft. 9 in. 1114 ft.		0 ft. 5 in. 95 ft.	
1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
4·23	5·44	3·75	2·80	3·63	3·18	3·42	2·87	4·50	3·70	6·70	4·48	2·51	2·13
6·08	·75	6·15	·80	3·60	·89	4·63	1·01	7·70	1·10	6·16	·87	3·91	1·30
1·82	1·98	2·65	1·90	2·52	1·81	2·33	2·00	2·70	2·30	2·62	·69	1·70	2·48
1·05	·78	1·70	·10	1·98	·24	1·94	·27	2·20	·60	3·29	1·74	2·34	·82
2·40	2·43	2·85	3·30	3·02	2·23	1·31	2·14	3·60	2·80	3·91	6·18	2·87	2·63
5·20	1·40	4·30	1·25	4·37	1·37	3·75	1·00	6·20	·90	5·49	2·83	3·06	1·02
3·41	4·06	2·15	5·10	1·72	4·70	1·88	3·15	2·60	5·60	2·38	4·21	1·66	4·13
2·88	2·67	2·70	3·00	2·11	2·66	2·25	2·73	2·80	2·70	3·64	2·64	3·08	4·82
4·79	3·31	4·65	3·70	4·61	4·65	4·75	6·26	4·10	5·00	5·78	7·27	5·81	3·66
4·98	4·20	3·00	2·70	3·34	2·79	2·50	2·85	4·30	3·30	4·83	3·89	4·10	2·59
5·80	1·38	4·70	1·90	4·63	2·59	4·82	2·45	5·90	3·30	7·26	4·82	5·71	3·93
5·56	2·69	4·20	1·85	3·45	1·84	3·65	1·90	6·10	2·00	7·19	3·16	3·06	1·77
48·20	31·09	42·80	28·40	38·98	28·95	37·23	28·63	52·70	33·30	59·25	42·78	39·81	31·28

SCOTLAND.

	Division XVII.—North-Eastern Counties (*continued*).								Div. XVIII.—North-Western Counties.			
	Aberdeen (*continued*).				Banff.		Elgin.		Ross and Cromarty.			
Height of Rain-gauge above	Leochel, Cushnie.		Tillydesk, Ellon.		Gordon Castle.		Grantown.		Inverinate House, Loch Alsh.		Gairloch.	
Ground ...... Sea-level......	3 ft. 0 in. 882 ft.		0 ft. 4 in. 349 ft.		1 ft. 6 in. 70 ft.		1 ft. 1 in. 712 ft.		3 ft. 0 in. 150 ft.		6 ft. 0 in. 13 ft.	
	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	3.61	1.84	3.01	1.91	3.24	1.25	2.37	1.04	11.08	12.37	11.13	5.69
February ...	5.39	1.43	3.74	1.98	1.36	1.43	.60	1.30	4.43	1.85	3.76	1.52
March	3.28	2.22	2.81	2.43	2.51	2.22	1.56	1.93	1.85	3.20	3.67	2.08
April	3.96	1.67	2.91	1.21	2.27	1.56	3.71	2.99	3.45	2.03	3.00	2.28
May	5.55	4.44	4.85	2.77	4.01	3.60	3.65	3.39	6.97	5.98	3.79	2.32
June	4.29	1.17	4.12	1.18	6.13	1.73	5.62	3.58	8.32	7.38	13.42	3.72
July	2.61	5.12	1.98	4.19	1.85	3.06	2.29	3.98	3.45	5.04	6.60	3.40
August	3.47	3.06	2.98	4.33	4.02	2.94	3.67	2.26	3.35	9.35	2.44	4.90
September ...	6.46	4.67	5.86	4.02	5.63	4.83	8.10	5.00	11.25	6.71	9.21	5.47
October	4.69	2.95	4.26	3.26	6.00	3.26	4.33	2.89	9.60	11.07	7.34	7.27
November ...	7.06	4.25	5.03	3.53	4.17	4.17	5.01	3.45	7.65	7.40	5.78	3.86
December ...	4.60	2.37	4.30	1.56	2.48	2.26	1.72	2.47	5.55	15.75	3.89	6.20
Totals	54.97	35.19	45.85	32.37	43.67	32.31	42.63	34.28	76.95	88.13	74.03	48.71

	Division XVIII.—North-Western Counties (*continued*).						Division XIX.—Northern Counties.					
	Inverness (*continued*).						Sutherland.					
Height of Rain-gauge above	Island Glass, Harris.		Corrimony, Glen Urquhart.		Laggan.		Dunrobin.		Scourie.		Cape Wrath.	
Ground ...... Sea-level......	3 ft. 4 in. 50 ft.		0 ft. 7 in. 540 ft.		0 ft. 9 in. 821 ft.		0 ft. 3 in. 6 ft.		0 ft. 3 in. 26 ft.		3 ft. 6 in. 355 ft.	
	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	9.03	4.84	8.45	9.90	5.28	7.49	2.80	2.02	6.10	4.50	5.61	3.93
February ...	3.60	.91	3.60	.40	3.05	2.88	2.00	2.20	1.00	1.60	1.62	.20
March	2.79	1.45	1.30	.90	1.75	2.22	1.20	1.31	1.70	2.50	2.13	2.52
April	3.00	1.11	1.80	.90	3.28	3.42	1.60	1.80	2.30	1.30	2.33	.83
May	2.83	1.51	3.00	1.50	3.24	4.29	1.43	2.52	1.60	2.70	7.70	2.20
June	4.28	3.20	5.80	2.30	3.63	5.83	5.42	1.73	4.10	2.00	3.61	2.29
July	3.52	4.50	3.40	3.00	5.49	5.10	2.50	3.61	3.50	3.50	3.59	.95
August	1.84	4.57	2.40	2.80	3.87	4.65	1.83	3.82	2.00	4.80	2.47	4.86
September ...	4.00	2.89	5.50	4.70	8.32	5.34	3.50	3.30	5.60	3.20	4.25	5.47
October	5.35	7.34	5.80	5.20	6.09	4.08	5.00	3.30	7.90	6.60	5.35	8.33
November ...	4.94	4.10	6.50	4.60	9.20	4.52	5.80	4.96	3.50	2.10	4.15	4.05
December ...	3.70	6.51	5.25	6.80	8.34	5.11	2.70	3.60	2.90	6.10	2.75	6.09
Totals	48.88	42.93	52.80	43.00	61.54	54.93	35.78	34.17	42.20	40.90	45.56	41.72

SCOTLAND.

Division XVIII.—North-Western Counties (*continued*).

Ross and Cromarty (*continued*).						Inverness.							
Lochbroom.		Cromarty.		Ardross Castle, Alness.		Oronsay.		Barrahead.		Ushenish, South Uist.		Culloden House.	
0 ft. 8 in. 48 ft.		3 ft. 4 in. 28 ft.		1 ft. 0 in. 450 ft.		0 ft. 6 in. 15 ft.		3 ft. 0 in. 640 ft.		0 ft. 4 in. 157 ft.		3 ft. 0 in. 104 ft.	
1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
5·90	6·81	1·99	1·55	3·37	2·86	6·16	17·30	5·24	3·84	7·82	5·98	2·54	1·52
2·12	2·36	·71	·57	3·26	·91	4·75	·76	3·77	·45	7·22	·90	·52	·82
1·62	1·43	1·03	1·02	2·04	1·75	3·00	3·40	1·60	1·64	2·48	1·71	·84	1·50
2·83	3·05	·89	·62	3·34	3·34	4·67	3·20	3·62	·60	4·15	1·23	·92	·87
3·91	2·38	2·59	2·28	3·09	5·50	6·77	4·75	1·40	1·37	2·73	2·19	3·63	3·18
5·66	2·49	4·69	1·13	6·35	2·69	6·92	7·36	4·07	1·48	3·35	3·83	4·94	1·45
1·80	3·54	2·81	2·58	3·15	4·68	6·58	6·30	3·01	3·74	3·70	6·45	3·14	3·50
2·77	5·75	1·58	1·58	2·39	4·09	4·74	10·50	1·61	3·00	2·35	5·11	2·41	1·98
6·90	5·07	3·10	4·42	5·75	6·60	10·00	5·87	5·15	1·95	6·54	3·96	3·76	5·57
7·72	9·80	3·35	2·76	4·83	5·71	9·66	10·06	4·60	3·66	7·00	6·85	3·37	2·30
6·67	5·16	3·85	2·85	6·03	3·13	14·96	11·56	3·90	3·19	6·61	4·72	4·34	3·18
3·35	8·16	1·29	2·25	2·61	3·53	5·00	19·30	2·80	2·91	4·67	4·91	1·44	2·51
51·25	56·00	27·88	23·61	46·21	44·79	83·21	100·36	40·77	27·83	58·62	47·84	31·85	28·38

Division XIX.—Northern Counties (*continued*).

Caithness.						Orkney.				Shetland.			
Nosshead.		Holburnhead.		Pentland Skerries.		Balfour Castle.		Sandwick Manse.		Stourhead.		Bressay.	
3 ft. 4 in. 127 ft.		0 ft. 4 in. 60 ft.		3 ft. 3 in. 72 ft.		0 ft. 6 in. 50 ft.		2 ft. 0 in. 78 ft.		....		0 ft. 4 in. 60 ft.	
1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
2·95	1·67	2·60	1·50	3·35	2·15	5·30	2·10	4·44	3·52	3·60	9·60	5·96	4·70
1·55	1·03	1·60	·50	1·80	·65	3·10	·10	2·16	1·54	1·40	1·00	3·51	1·54
1·78	1·65	1·20	2·40	1·32	2·30	1·60	1·90	2·04	2·20	1·50	3·00	1·78	3·93
1·88	1·71	2·50	1·80	2·81	·20	3·10	·80	2·40	1·44	·80	2·10	3·65	1·79
1·11	1·43	1·50	2·00	1·48	1·97	1·60	1·10	1·69	1·71	2·40	3·40	2·81	1·83
4·54	1·35	3·00	1·60	2·08	1·31	4·00	1·20	3·52	1·82	1·60	5·70	4·20	1·66
2·45	1·58	2·40	1·40	2·55	1·39	2·10	2·00	2·60	2·39	3·40	5·70	3·07	4·37
2·67	3·40	2·10	3·30	2·49	2·10	3·10	2·20	3·40	4·06	·80	4·80	4·60	5·03
3·22	2·92	4·00	4·90	2·68	2·23	3·40	2·80	3·50	3·51	2·30	3·10	4·20	3·33
3·55	5·32	5·50	6·40	5·07	3·78	6·20	6·20	4·72	6·56	4·90	4·60	5·69	4·51
3·52	3·92	3·70	4·70	4·54	4·10	5·10	4·70	5·02	4·69	4·70	3·60	4·39	2·57
3·61	2·49	5·10	3·40	3·97	3·32	6·20	4·20	4·41	4·29	5·20	6·40	5·22	5·23
32·83	28·47	35·20	33·90	34·14	25·50	44·80	29·30	39·90	37·73	32·60	53·00	49·08	40·49

IRELAND.

	Division XX.—Munster.										Div. XXI.—Leinster.	
	Cork.				Kerry.		Waterford.		Clare.		Carlow.	
Height of Rain-gauge above	Cork, Queen's College.		Fermoy.		Darrynane.		Waterford.		Killaloe.		Fenagh House, Bagnalstown.	
Ground ...... / Sea-level......	6 ft. 0 in. / 65 ft.		4 ft. 0 in. / 114 ft.		1 ft. 1 in. / 12 ft.		4 ft. 6 in. / 60 ft.		5 ft. 0 in. / 123 ft.		1 ft. 0 in. / 340 ft.	
	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	7·26	9·70	4·94	7·47	7·81	7·79	6·94	8·01	6·44	7·72	5·22	4·95
February ...	5·32	1·46	5·11	2·24	5·62	4·49	5·52	2·92	4·59	2·01	4·96	1·44
March	3·80	4·85	3·51	3·83	4·67	4·65	5·46	3·87	2·92	3·98	3·21	2·99
April	1·11	1·98	1·26	1·80	1·72	2·26	3·04	1·02	2·46	2·71	2·76	·87
May	1·50	1·47	1·30	1·21	2·45	3·03	1·41	1·36	2·44	3·09	1·78	2·20
June	3·52	2·43	2·68	1·54	5·27	2·99	3·20	1·44	4·73	2·91	4·39	1·18
July	6·94	3·40	4·54	2·96	5·72	6·07	2·76	3·73	1·88	4·18	2·09	3·49
August	6·83	3·24	4·59	3·85	5·38	5·95	4·25	6·00	5·01	8·61	5·40	6·09
September ...	3·16	2·80	2·26	2·22	5·04	6·59	3·20	3·39	4·59	5·26	3·41	2·48
October	5·27	2·17	3·15	3·04	8·11	6·95	3·30	4·19	5·70	6·57	3·56	3·35
November ...	6·27	2·52	4·89	2·07	6·50	4·41	6·24	3·17	5·51	3·18	5·48	2·16
December ...	10·59	·77	8·37	·87	8·73	1·86	11·08	1·16	6·78	2·51	9·66	·80
Totals	61·57	36·79	46·60	33·10	67·02	57·04	56·40	40·26	53·05	52·73	51·92	32·00

	Division XXII.—Connaught (*continued*).						Division XXIII.—Ulster.					
	Roscommon.		Mayo.		Sligo.		Cavan.		Enniskillen.		Antrim.	
Height of Rain-gauge above	Holywell.		Doo Castle.		Mount Shannon, Sligo.		Red Hills, Belturbet.		Florence Court.		Aghalee, Lurgan.	
Ground ...... / Sea-level......	5 ft. 0 in. /		1 ft. 0 in. /		4 ft. 5 in. / 70 ft.		0 ft. 9 in. / 208 ft.		1 ft. 11 in. / 250 ft.		1 ft. 0 in. / 105 ft.	
	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	5·31	3·09	6·44	5·01	5·91	6·16	5·67	5·29	9·17	9·92	5·05	3·90
February ...	2·27	1·18	3·60	1·02	3·83	·79	3·16	·80	4·50	·95	3·31	·66
March	2·66	2·99	4·70	2·83	3·01	2·53	2·31	2·45	3·62	2·02	2·61	2·11
April	·56	·99	1·16	1·29	2·08	1·43	2·30	1·41	1·56	1·12	3·54	·62
May	2·57	2·10	2·43	2·45	2·29	2·37	1·94	1·74	3·40	1·32	3·15	1·78
June	3·48	1·69	3·96	1·39	6·15	1·60	4·04	1·42	5·17	1·39	3·98	1·97
July	1·75	5·00	2·15	4·23	1·81	3·82	1·50	3·73	1·74	4·43	2·43	7·17
August	4·02	2·99	4·28	5·35	3·79	7·02	3·25	5·62	6·51	7·20	3·40	4·95
September ...	5·11	2·62	6·96	2·42	7·17	2·38	5·50	3·20	6·63	3·03	4·59	2·91
October	5·68	4·90	6·33	4·81	6·97	7·03	4·37	2·77	5·11	3·91	4·58	2·77
November ...	4·33	1·20	5·82	1·86	5·33	2·29	3·73	2·05	5·90	2·61	4·13	2·35
December ...	5·22	1·00	5·03	1·63	5·49	1·16	5·30	1·13	7·69	2·36	6·02	·75
Totals	42·96	29·75	52·86	34·29	53·83	38·58	43·07	31·61	61·00	40·26	46·79	31·94

IRELAND.

Division XXI.—Leinster (*continued*).										Division XXII.—Connaught.			
Carlow (*continued*).		King's Co.				Wicklow.		Dublin.		Galway.			
Brown's Hill, Carlow.		Portarlington.		Tullamore.		Fassaroe, Bray.		Black Rock.		Cregg Park.		Galway, Queen's College.	
1 ft. 0 in. 291 ft.		1 ft. 2 in. 240 ft.		3 ft. 0 in. 235 ft.		5 ft. 0 in. 250 ft.		29 ft. 0 in. 90 ft.		3 ft. 0 in. 130 ft.		9 ft. 0 in. 30 ft.	
1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
4·43	4·92	2·63	4·32	3·45	5·22	4·97	4·37	3·74	3·71	5·64	7·06	6·63	7·13
4·61	·88	3·12	·49	2·41	·82	4·97	1·35	3·91	·50	3·61	1·64	3·93	1·51
2·84	3·16	2·44	3·24	2·11	3·49	2·88	3·24	2·41	2·78	1·85	2·95	2·72	3·13
2·57	1·26	2·33	2·14	2·10	2·19	3·25	·53	3·02	·85	1·60	2·16	1·70	3·22
1·46	2·12	1·92	1·78	1·87	1·72	2·48	·84	1·97	·81	3·24	2·41	2·30	2·40
3·32	1·10	3·21	1·47	3·99	1·12	3·25	1·04	2·92	·45	4·43	2·23	6·09	3·54
2·40	3·29	2·62	3·17	2·14	3·96	1·40	3·13	1·12	4·42	2·31	5·14	2·80	6·47
4·89	6·33	3·61	4·33	3·51	4·22	3·79	4·18	4·31	3·88	3·39	5·40	5·25	6·28
3·60	2·28	2·59	1·76	2·51	2·55	3·13	2·46	2·68	2·32	3·56	3·21	6·90	4·14
4·04	3·19	4·22	3·58	3·85	4·62	5·04	3·28	4·23	2·41	4·48	5·32	6·45	5·50
4·95	1·55	3·39	2·13	3·59	2·30	6·51	2·77	5·19	2·33	4·18	1·94	5·77	2·92
8·18	·93	5·64	1·09	4·15	·91	8·83	·55	6·82	·50	5·88	1·28	5·83	1·84
47·29	31·01	37·72	29·50	35·68	33·12	50·50	27·74	42·32	24·96	44·17	40·74	56·37	48·08

Division XXIII.—Ulster (*continued*).													
Antrim (*continued*).				Londonderry.				Tyrone.		Donegal.			
Antrim.		Belfast, Queen's College.		Monedig, Garvagh.		Londonderry.		Omagh.		Dungloe.		Moville.	
1 ft. 0 in. 150 ft.		7 ft. 4 in. 68 ft.		1 ft. 0 in. 120 ft.		0 ft. 3 in. 80 ft.		1 ft. 0 in. 275 ft.		0 ft. 6 in. 10 ft.		4 ft. 0 in. 100 ft.	
1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.	1872.	1873.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
4·18	3·73	4·26	3·58	6·58	4·56	6·02	5·20	5·65	4·69	8·26	6·00	6·69	4·11
3·14	·54	3·55	·76	3·89	1·29	3·05	·86	3·65	·77	3·77	·83	2·79	1·45
3·27	1·87	1·79	2·23	3·16	2·29	3·25	2·62	2·00	2·01	3·40	2·71	3·68	2·38
3·83	·80	2·59	·33	3·44	·81	2·70	·75	2·49	·56	1·41	1·30	4·10	·90
2·15	1·92	2·60	2·12	3·44	2·61	2·90	2·10	1·90	2·36	2·79	3·32	3·26	3·67
3·70	1·67	4·17	1·81	4·78	1·61	3·65	2·20	5·27	2·14	5·60	2·18	4·77	1·62
1·61	6·58	3·05	5·10	2·08	4·82	1·25	5·04	1·50	4·43	1·11	5·04	2·39	4·60
4·05	5·41	3·25	5·63	4·50	5·73	4·15	6·50	3·05	6·15	4·63	7·02	4·77	5·90
4·47	1·92	4·28	2·44	6·90	3·61	4·90	3·75	6·71	4·13	7·65	4·15	9·28	4·59
4·98	3·93	5·10	3·97	5·95	4·58	4·30	5·90	4·47	4·00	5·05	7·48	5·30	7·30
2·74	2·65	4·53	2·55	5·27	2·02	4·30	2·40	5·30	2·09	5·02	3·85	6·68	2·68
4·48	1·04	5·29	·61	5·01	2·03	3·20	2·75	4·20	1·55	4·08	3·33	3·80	2·99
42·60	32·06	44·46	31·13	55·00	35·96	43·67	40·07	46·19	34·88	52·77	47·21	57·51	42·19

EXAMINATION OF

Reference number.	Date of examination.	COUNTY. Station. *OWNER.* *Observer.*	Construction of gauge.	Maker's name.	Time of reading.	Height of gauge. Above ground.	Above sea-level.
						ft. in.	feet.
480.	1872. Dec. 4.	OXFORDSHIRE. Banbury, Parson Street. *J. JARVIS, ESQ.* *J. Jarvis, Esq.*	II.	....	9 a.m.	4 6	350
481.	Dec. 4.	OXFORDSHIRE. Banbury, Parson Street. *J. JARVIS, ESQ.* *J. Jarvis, Esq.*	II.	....	....	4 0	350
482.	Dec. 5.	HERTFORDSHIRE. Rothamsted. *J. B. LAWES, ESQ., F.R.S.*	XI.	....	9 a.m. and 4.30 p.m.	2 0	420
483.	1873. July 13.	KENT. Harefield, Selling. *E. NEAME, ESQ.* *E. Neame, Esq.*	XII.	Casella	9 a.m.	2 6	217
484.	July 13.	KENT. Sheldwich Vicarage. *REV. B. S. MALDEN.* *Rev. B. S. Malden.*	III.	Casella	9 a.m.	1 0	259
485.	Aug. 14.	SUSSEX. Crowborough Beacon Observatory. *C. L. PRINCE, ESQ.* *C. L. Prince, Esq.*	VI.	....	9 a.m.	6 0	777
486.	Aug. 15.	SUSSEX. Uckfield Observatory. *C. L. PRINCE, ESQ.* *C. L. Prince, Esq.*	VI.	....	9 a.m.	6 3	149
487.	Aug. 15.	SUSSEX. The Grange, Framfield. *CAPT. DRAKE.* *Capt. Drake.*	X.	Negretti & Zambra	....	1 2	185
488.	Aug. 15.	SUSSEX. Buxted Park. *COL. HARCOURT.* *Mr. J. Edmeads.*	X.	Negretti & Zambra	9 a.m.	1 0	193
489.	Sept. 29.	WESTMORELAND. Mardale Green. *BRITISH ASSOCIATION.* *Mr. Hebson.*	I.	Casella	9 a.m. 1st of month.	1 0	800
490.	Sept. 29.	WESTMORELAND. Measandbecks, Haweswater. *BRITISH ASSOCIATION.* *Mr. J. Rigg.*	I.	Casella	9 a.m. 1st of month.	1 2	1200

RAIN-GAUGES (*continued from Brit. Assoc. Rep.* 1873, p. 303).

Diameters (that marked M=mean).	Equivalents of water. Scale-point.	Grains.	Error at scale-point specified in previous column.	Azimuth and angular elevation of objects above mouth of rain-gauge.	Remarks on position &c.	Reference number.
in.	in.		in.			
9·92	·1	1760	+·012	....	In garden in centre of town, fair exposure.	480.
10·06	·2	3523	+·024			
10·02	·3	5283	+·037			
9·92	·4	7045	+·049			
M 9·980	·5	8805	+·061			
10·10	·1	1980	+·002	....	Close to 480.	481.
10·15	·2	3954	+·003			
10·00	·3	5930	+·005			
10·03	·4	7908	+·007			
M 10·070	·5	9885	+·009			
4·93	....	....	....	....	Gauge in large experimental field. Measuring-glass not accessible; said to have been verified in the laboratory.	482.
4·98						
4·98						
5·01						
M 4·975						
5·02	·1	495	correct.	S. Tree, 46°.	Position not good, but no better available for daily observations. Establishment of a monthly gauge at a little distance suggested.	483.
4·98	·2	990	correct.	S.E. „ 35°.		
4·99	·3	1470	+·003			
5·01	·4	1970	+·003			
M 5·000	·5	2450	+·006			
5·00	·1	490	+·001	....	All clear, S.E. of church and within 100 yards of it.	484.
4·95	·2	980	+·002			
5·09	·3	1470	+·002			
4·92	·4	1970	+·001			
M 4·990	·5	2470	correct.			
11·20	·1	2265	+·010	....	This gauge not in use, being considered incorrect.	485.
11·28	·2	4550	+·019			
11·32	·3	6825	+·028			
11·22	·4	9100	+·038			
M 11·255	·5	11375	+·047			
11·28	·1	2450	+·002	N.W. Chestnut, 25°	....	486.
11·21	·2	4940	+·002	S.E. Apple, 24°.		
11·23	·3	7300	+·008			
11·19	·4	9720	+·011			
M 11·228						
7·88	·1	1280	−·001	W.N.W. Tree, 15°.	On lawn; no better position available.	487.
8·13	·2	2500	+·003	N.W.-N.N.W. Ho. 45°		
7·96	·3	3790	+·001	N. Trees, 30°.		
8·02	·4	5100	−·002			
M 7·998	·5	6330	+·001			
8·04	·1	1360	−·007	S.W. Tree, 48°.	Gauge to be moved further northwards; on lawn N. of house.	488.
8·03	·2	2550	−·001	N.E. Fir, 31°.		
8·00	·3	3800	correct.			
7·92	·4	5040	+·003			
M 7·998	·5	6250	+·007			
8·00	....	....	....	E.S.E. Hill, 31°.	Else clear. Rod and gauge correct.	489.
7·98	....	....	....	S.S.E. Firs, 36°.		
8·03						
8·00						
M 8·002						
7·92	....	....	....	....	The gauge was moved two years ago; rod correct and gauge true.	490.
8·07						
8·00						
7·98						
M 7·993						

EXAMINATION OF

Reference number.	Date of examination.	COUNTY. Station. *OWNER.* *Observer.*	Construction of gauge.	Maker's name.	Time of reading.	Height of gauge. Above ground.		Height of gauge. Above sea-level.
	1873.					ft.	in.	feet.
491.	Sept. 30.	WESTMORELAND. Crosby Ravensworth. *REV. G. F. WESTON.* *Rev. G. F. Weston.*	X.	Baker	....	1	0	600
492.	Sept. 30.	WESTMORELAND. Reagill. *MR. W. WILKINSON.* *Mr. W. Wilkinson.*	X.	Baker	9 a.m.	0	10	890
493.	Oct. 3.	WESTMORELAND. Belsfield, Windermere. *H. W. SCHNEIDER, ESQ.* *Mr. Chaplin.*	XII.	Casella	9 a.m.	4	6	160
494.	Oct. 3.	LANCASHIRE. Backbarrow, Cartmell. *MAJOR AINSWORTH.*	IV.	Hartley	....	3	2	70
495.	Oct. 4.	LANCASHIRE. Lanehead, Coniston. *R. T. BYWATER, ESQ.* *R. T. Bywater, Esq.*	XI.	Negretti & Zambra	....	1	0	287
496.	Oct. 4.	LANCASHIRE. Lanehead, Coniston. *R. T. BYWATER, ESQ.* *R. T. Bywater, Esq.*	X.	Negretti & Zambra	9 a.m.	1	0	287
497.	Oct. 9.	WESTMORELAND. Greenside Mines. *MR. TAYLOR.* *Mr. Taylor.*	X.	Casella	1st of month.	1	0	1000
498.	Oct. 11.	CUMBERLAND. Barrow House. *S. Z. LANGTON, ESQ.*	X.	Negretti & Zambra	9 a.m.	0	6	282
499.	Oct. 13.	CUMBERLAND. Brow Top, Keswick. *W. SHERWIN, ESQ.* *Mr. J. Barker.*	III.	Cook	8 a.m.	0	8	407
500.		CUMBERLAND. Shu-le-Crow, Keswick. *H. DAWSON, ESQ.* *H. Dawson, Esq.*	IV.	Chadburn	9 a.m.	3	0	278
501.	Oct. 20.	CUMBERLAND. The Stye. *ISAAC FLETCHER, ESQ., M.P.* *Mr. J. Wilson.*	....	Cook	1st of month.	1	0	1077

RAIN-GAUGES (*continued*).

Diameters (that marked M = mean).	Equivalents of water. Scale-point.	Grains.	Error at scale-point specified in previous column.	Azimuth and angular elevation of objects above mouth of rain-gauge.	Remarks on position &c.	Reference number.
in.	in.		in.			
7·92	·1	1250	+·001	S.E. Stables, 28°.	S.E. of church; gauge in garden, clear except as noted.	491.
8·00	·2	2550	−·002	W.N.W. Belt of trees, 25°.		
8·02	·3	3780	+·001			
8·00	·4	5030	+·002			
M 7·985	·5	6300	+·002			
7·98	·1	1310	−·003	S. House, 20°.	In field, quite clear except as noted.	492.
8·00	·2	2550	−·001			
8·00	·3	3780	+·002			
8·00	·4	5100	−·002			
M 7·995	·5	6340	correct.			
5·00	·1	500	−·001	....	In gardens, quite clear.	493.
5·00	·2	1000	−·002			
5·00	·3	1490	−·001			
5·00	·4	2000	−·003			
M 5·000	·5	2470	+·002			
12·10	·082	780	+·056	E. Fir, 54°.	In garden, very much shut in by trees. Gauge out of order, and believed to have been subsequently abandoned.	494.
12·05	·110	1650	+·052	S. „ 34°.		
12·05	·138	2570	+·047	W. „ 0°.		
11·90	....	....	....	N.W. Trees, 58°.		
M 12·025	....	....	....	N. House, 10°.		
4·98	·1	490	+·002	....	Quite open, on lawn.	495.
5·00	·2	990	+·001			
5·02	·3	1470	+·005			
5·04	·4	1960	+·006			
M 5·010	·5	2470	+·004			
7·98	·1	1290	−·002	....	Close to 495.	496.
8·02	·2	2560	−·002			
8·03	·372	4730	−·001			
7·97	·5	6250	−·008			
M 8·000						
7·00	·1	1090	−·012	....	On N. slope of valley, but near its bottom; unsheltered except by the ground, which runs up at perhaps 45° to between 1500 and 2000 feet.	497.
6·99	·2	2000	−·006			
7·02	·3	3000	−·008			
7·00	·4	3900	−·001			
M 7·002	·5	4900	−·003			
7·98	·1	1260	+·001	E. Shrubbery, 53°.	Position not good, but no better available near the house.	498.
8·02	·2	2540	correct.	S. Oak, 48°.		
7·98	·3	3800	+·001			
8·02	·4	5048	+·002			
M 8·000	·5	6300	+·004			
5·01	·1	490	+·002	....	Clear; on N. corner of lawn.	499.
5·05	·2	970	+·007			
5·01	·3	1480	+·005			
5·05	·4	1980	+·005			
M 5·030	·5	2470	+·008			
12·00	·09	3000	−·015	....	In garden on bank of Derwent, quite clear.	500.
12·00	·19	6000	−·020			
11·99	·295	9000	−·020			
12·01	·406	12000	−·014			
M 12·000	·51	15000	−·015			
4·00	....	....	....	....	Measuring-glass not accessible. Gauge concealed among rocks on the eastern slope of the Stye Head Pass.	501.
4·00						
3·99						
4·01						
M 4·000						

EXAMINATION OF

Reference number.	Date of examination.	COUNTY. Station. *OWNER.* *Observer.*	Construction of gauge.	Maker's name.	Time of reading.	Height of gauge. Above ground.	Above sea-level.
	1873.					ft. in.	feet.
502.	Oct. 22.	CUMBERLAND. Deer Close, Keswick. *H. C. MARSHALL, ESQ.*	XII.	Casella	9 a.m.	1 8	300
503.	Oct. 23.	YORKSHIRE. Moorside, Halifax. *L. J. CROSSLEY, ESQ.* *Mr. Page.*	X.	....	9 a.m.	1 0	429
504.	Oct. 24.	YORKSHIRE. Settle.	III.	....	....	8 0	519
505.	Oct. 24.	YORKSHIRE. Langcliffe, Settle. *MISS SEDGWICK.* *Miss Sedgwick.*	X.	Negretti & Zambra	....	1 6	623
506.	Oct. 25.	YORKSHIRE. Cherry Hill, York. *H. RICHARDSON, ESQ.*	III.	....	9 a.m.	1 6	40
507.	Oct. 25.	YORKSHIRE. Cherry Hill, York. Second gauge. *H. RICHARDSON, ESQ.* *H. Richardson, Esq.*	III.	....	9 a.m.	2 0	40
508.	Nov. 1.	NOTTINGHAM. Southwell. *W. W. P. CLAY, ESQ.* *W. W. P. Clay, Esq.*	III.	Davis	....	....	....
	1874.						
509.	Mar. 31.	YORKSHIRE. Penistone. *M. S. & L. R. Co.*	VIII.	Casartelli	8 a.m.	3 6	717
510.	Mar. 31.	YORKSHIRE. Carlcotes. *M. S. & L. R. Co.*	VIII.	Casartelli	....	2 11	1075
511.	Mar. 31.	YORKSHIRE. Dunford Bridge Reservoir. *DEWSBURY WATER Co.* *Mr. G. Whitfield.*	II.	....	9 a.m.	2 0	1100
512.	Apr. 1.	YORKSHIRE. Dunford Bridge Station. *M. S. & L. R. Co.*	VIII.	Casartelli	9 a.m.	3 6	954

RAIN-GAUGES (*continued*).

Diameters (that marked M = mean).	Equivalents of water.		Error at scale-point specified in previous column.	Azimuth and angular elevation of objects above mouth of rain-gauge.	Remarks on position &c.	Reference number.
	Scale-point.	Grains.				
in.	in.		in.			
6·96	·1	970	correct.	N.E. House, 32°.	Good position in front of house. Set on a large stone, which had sunk towards S.W.: requested that it might be rendered level. On edge of lawn, quite clear.	502.
7·00	·2	1960	—·002			
6·95	·3	2940	—·004			
7·00	·4	3880	—·002			
M 6·978	·5	4855	—·002			
8·04	·1	1260	+·001	....	....	503.
7·90	·2	2520	+·002			
8·03	·3	3800	—·002			
7·96	·4	5040	+·003			
M 7·983	·5	6260	+·012			
5·00	·1	496	correct.	....	On a bracket from west eaves of cottage. Gauge was tipping one inch to the west. Believed to belong to contractor of Settle and Carlisle Railway.	504.
5·00	·3	1490	correct.			
5·01	·5	2450	+·006			
5·01						
M 5·005						
8·00	·1	1255	+·003	N. House, 22°.	Gauge in dwarf stump. Good position in garden.	505.
8·02	·2	2520	+·004	S.E. Laburnum, 16°		
8·00	·3	3800	+·002	W. Tree, 13°.		
7·98	·4	5100	—·004			
M 8·000	·5	6310	+·007			
4·96	·1	450	+·008	W. Tree, 58°.	In garden, too much sheltered by trees; better spot selected.	506.
5·02	·2	948	+·007	S. „ 38°.		
4·94	·3	1415	+·012	E. „ 50°.		
5·01	·4	1915	+·011	N. „ 30°.		
M 4·983	·5	2400	+·012			
5·02	·1	450	+·011	....	Close to 506.	507.
5·07	·2	948	+·012			
5·00	·3	1415	+·019			
5·05	·4	1915	+·019			
M 5·035	·5	2400	+·023			
6·05	.05	440	—·011	....	The measure supplied with the gauge was broken shortly after, and a memorandum was made previously that 0·25 in. in measure = 5 oz. in the large graduated measure, which holds 8 oz. The memorandum probably should have been that 0·25 in. = 4 oz., instead of 5 oz., a most serious error.	508.
6·00	·1	880	—·022			
6·05	·2	1750	—·042			
6·05	·3	2630	—·064			
M 6·037	·4	3500	—·098			
8·50	·1	1280	+·012	....	E.N.E. of church, in the yard of the old station.	509.
8·48	·2	2600	+·017			
8·58	·3	3860	+·030			
8·42	·4	5270	+·032			
M 8·495	·5	6580	+·043			
8·70	....	....	....	....	Gauge not firmly fixed.	510.
8·48	·1	1510	—·005			
8·43	·2	3020	—·010			
8·42	·3	4290	+·001			
M 8·507	·394	5740	—·006			
11·92	....	....	....	....	Same gauge and in same position as when visited April 9th, 1869. See No. 299.	511.
12·02						
12·00						
11·93						
M 11·968						
8·45	·1	1450	—·001	....	Since previous testing (No. 293) a new glass has been provided, and the funnel either bent or renewed.	512.
8·55	·2	2790	+·005			
8·42	·3	4300	correct.			
8·60	·4	5780	—·003			
M 8·505	·45	6450	correct.			

EXAMINATION OF

Reference number.	Date of examination.	COUNTY. Station. *OWNER.* *Observer.*	Construction of gauge.	Maker's name.	Time of reading.	Height of gauge. Above ground.		Above sea-level.
						ft.	in.	feet.
513.	1874. Apr. 1.	YORKSHIRE. Border Hill, Swinden. *WAKEFIELD NEW WATER Co.*	III.	Negretti & Zambra	9 a.m.	....		....
514.	Apr. 1.	YORKSHIRE. Swinden Lodge. *WAKEFIELD NEW WATER Co.*	III.	Negretti & Zambra	8 a.m.	1	1	....
515.	Apr. 1.	YORKSHIRE. Langsett. *WAKEFIELD NEW WATER Co.*	III.	Negretti & Zambra	....	1	1	....
516.	June 16.	YORKSHIRE. Gibbet, Halifax. *HALIFAX CORPORATION.* *J. E. Lambert, Esq.*	XII.	Guest & Chrimes	9 a.m.	5	0	568
517.	June 16.	YORKSHIRE. Victoria Reservoir, Halifax. *HALIFAX CORPORATION.* *Mr. G. Moore.*	XII.	Guest & Chrimes	9 a.m.	1	0	795
518.	June 16.	YORKSHIRE. Ramsden Wood, Halifax. *HALIFAX CORPORATION.* *Mr. E. Dennis.*	X.	Negretti & Zambra	9 a.m.	1	2	805
519.	June 16.	YORKSHIRE. Ogden Reservoir, Halifax. *HALIFAX CORPORATION.* *Mr. John Smith.*	X.	....	9 a.m.	1	3	990
520.	June 16.	YORKSHIRE. Stansfield Hall, Todmorden. *J. FIELDEN, ESQ., M.P.* *Mr. W. Fielden.*	X.	Negretti & Zambra	9 a.m.	2	0	....
521.	June 17.	YORKSHIRE. Walshaw Dean. *HALIFAX CORPORATION.* *J. Midgeley.*	I.	....	Mondays and 1st of month.	0	3	1380
522.	June 17.	YORKSHIRE. Midgeley Moor. *HALIFAX CORPORATION.* *Mr. N. Greenwood.*	I.	....	Mondays and 1st of month.	0	6	1350
523.	June 17.	YORKSHIRE. Warley Moor. *HALIFAX CORPORATION.* *Mr. N. Greenwood.*	I	....	Mondays and 1st of month.	0	6	1425

RAIN-GAUGES (*continued*).

Diameters (that marked M=mean).	Equivalents of water. Scale-point.	Equivalents of water. Grains.	Error at scale-point specified in previous column.	Azimuth and angular elevation of objects above mouth of rain-gauge.	Remarks on position &c.	Reference number.
in.	in.		in.			
....	......	....	....	....	Site only of gauge inspected, the gauge having been broken and removed. Very open tableland, good position.	513.
5·04	·1	490	+·003	....	Rim of gauge rather flat. Gauge well exposed in open field.	514.
5·04	·2	1020	−·002			
5·04	·3	1500	+·002			
5·04	·4	2000	+·003			
M 5·040	·5	2500	+·004			
....	......	....	....	N.W.–N.E. Wall, 40°.	Site only inspected, which was extremely bad, a mere shelf-like path on the northern side of a gorge.	515.
4·98	·1	490	+·001	S. House, 33°.	Gauge erected on the base of the old Gibbet; site bad, but no better available.	516.
5·00	·2	960	+·006	S.W. House, 52°.		
4·97	·3	1450	+·006	N. Buildings, 12°.		
5·01	·4	1948	+·005	W. Buildings, 25°.		
M 4·990	·5	2450	+·004			
5·00	·1	460	+·007	....	Very open position on side of reservoir.	517.
5·00	·2	950	+·008			
5·00	·3	1450	+·007			
4·98	·4	1950	+·006			
M 4·995	·5	2435	+·008			
7·96	·1	1275	correct.	S. House, 33°.	Clear except as noted.	518.
8·02	·2	2550	−·001	W. Reservoir bank, 25°.		
8·04	·3	3820	−·001			
8·00	·4	5040	+·003			
M 8·005	·5	6320	+·003			
8·02	·1	1280	−·001	....	Very open position.	519.
8·00	·2	2520	+·002			
7·98	·3	3750	+·005			
8·03	·39	4900	+·005			
M 8·007						
7·98	·1	1320	−·004	....	In garden, quite unsheltered. Gauge old, and measuring-glass broken off at ·41.	520.
8·05	·2	2590	−·003			
7·92	·3	3760	+·005			
8·10	·4	5050	+·003			
M 8·012						
8·08	......	....	....	....	Gauge sunk in a box which was nearly level with the rim; put in sods to raise it 2 in. above the wood. Site quite open, and gauge correct.	521.
8·10						
8·10						
8·00						
M 8·07						
6·76	......	....	....	....	Gauge correct, and site very good.	522.
6·97						
6·86						
6·96						
M 6·888						
7·12	......	....	correct.	....	On open moor.	523.
7·06						
7·00						
7·00						
M 7·045						

EXAMINATION OF

Reference number.	Date of examination.	COUNTY. Station. *OWNER.* *Observer.*	Construction of gauge.	Maker's name.	Time of reading.	Height of gauge. Above ground.		Height of gauge. Above sea-level.
	1874.					ft.	in.	feet.
524.	June 17.	YORKSHIRE. Ovenden Moor. *HALIFAX CORPORATION.* *Mr. N. Greenwood.*	I.	....	Mondays and 1st of month.	0	6	1375
525.	July 30.	HAMPSHIRE. Ashdell, Alton. *F. CROWLEY, ESQ.* *F. Crowley, Esq.*	X.	Smith & Beck ...	9 a.m.	3	3	396
526.	July 30.	HAMPSHIRE. East Tisted Rectory, Alton. *REV. F. HOWLETT.* *Rev. F. Howlett.*	III.	Casella	....	1	3	420
527.	July 30.	HAMPSHIRE. The Wakes, Selborne. *T. BELL, ESQ., F.R.S.* *Mr. W. Binnie.*	Square V.	Anon................	9 a.m.	4	7	400
528.	July 30.	HAMPSHIRE. Chawton House, Alton. *MR. FRANCES.* *Mr. Frances.*	III.	Casella	9 a.m.	1	0	445
529.	July 31.	HAMPSHIRE. Wester Court, Alresford. *T. P. MAY, ESQ.* *T. P. May, Esq.*	X.	Negretti & Zambra	9 a.m.	0	9	253
530.	July 31.	HAMPSHIRE. Arle Bury, Alresford. *F. MARX, ESQ.* *Mr. Kinge.*	III.	Casella	9 a.m.	1	4	308
531.	July 31.	HAMPSHIRE. Otterbourn, Winchester. *J. B. YONGE, ESQ.* *J. B. Yonge, Esq.*	XII.	Casella	....	1	0	115
532.	July 31.	HAMPSHIRE. Otterbourne, Winchester. *J. B. YONGE, ESQ.*	III.	Casella	....	1	3	115
533.	Aug. 1.	HAMPSHIRE. Red Lodge, Southampton. *R. C. HANKINSON, ESQ.* *R. C. Hankinson, Esq.*	XII.	Casella	9 a.m.	0	5	200
534.	Aug. 1.	HAMPSHIRE. Red Lodge, Southampton. (Plantation Gauge.) *R. C. HANKINSON, ESQ.* *R. C. Hankinson, Esq.*	III.	Davis	9 a.m.	4	0	194

RAIN-GAUGES (*continued*).

Diameters (that marked M=mean).	Equivalents of water. Scale-point.	Equivalents of water. Grains.	Error at scale-point specified in previous column.	Azimuth and angular elevation of objects above mouth of rain-gauge.	Remarks on position &c.	Reference number.
in.	in.		in.			
7·10	....	....	correct.	....	On open flat moorland.	524.
7·00						
7·06						
7·10						
M 7·065						
7·98	·1	1290	−·002	S.S.W. Peas, 20°.	In garden, quite clear; ground level, but falling rapidly at a short distance.	525.
8·00	·2	2550	−·001			
8·01	·3	3800	correct.			
7·98	·4	5400	−·026			
M 7·993	·5	6340	correct.			
4·99	·1	495	correct.	S.E. Church-tower, 28°.	On lawn N.W. of church.	526.
5·00	·2	980	+·002			
4·97	·3	1480	+·001			
5·02	·4	1980	correct.			
M 4·995	·5	2470	+·001			
6·0009	·028	200	−·003	N.E. Yew, 38°. S.W. Hill wooded, 10°.	Position good, but glass very incorrect; a new one supplied.	527.
5·9509	·139	1320	−·024			
6·0409	·278	2740	−·061			
6·0109	·417	4050	−·083			
M 6·0039	·556	5210	−·087			
3·00	·1	180	correct.	....	Gauge not in use, but to be restarted August 1st, 1874. Fair position in garden.	528.
2·99	·2	340	+·010			
3·01	·3	520	+·010			
3·00	·4	692	+·013			
M 3·000	·5	865	+·017			
8·00	·1	1248	+·001	S.E. Firs, 48°.	On N. side of a sunk fence, and about 3 ft. from the edge; otherwise good position.	529.
7·98	·2	2500	+·003			
7·99	·3	3750	+·004			
8·00	·4	5010	+·005			
M 7·993	·5	6280	+·004			
5·01	·1	470	+·005	S.E. Limes, 42°.	In kitchen-garden; clear, except as noted.	530.
4·99	·2	980	+·002			
5·00	·3	1480	+·001			
5·00	·4	1950	+·007			
M 5·000	·5	2450	+·006			
5·00	·1	500	−·001	S.W. Trees, 32°. E.N.E. Peas, 30°.	Open position in kitchen-garden.	531.
5·01	·2	1000	−·002			
5·00	·3	1500	−·002			
5·00	·4	2000	−·003			
M 5·002	·5	2500	−·004			
4·94	....	....	....	....	Close to 531.	532.
5·00						
5·02						
4·97						
M 4·983						
5·03	·1	480	+·003	N.E. House, 25°.	On lawn; clear, except as noted.	533.
4·94	·2	1000	−·002			
4·98	·3	1470	+·003			
5·04	·4	1960	+·004			
M 4·998	·5	2460	+·003			
5·03	·1	490	+·001	....	In plantation, S.W. of house; clear at present.	534.
4·96	·2	1000	−·002			
4·99	·3	1460	+·004			
4·98	·4	1970	+·001			
M 4·990	·5	2450	+·004			

EXAMINATION OF

Reference number.	Date of examination.	COUNTY. Station. *OWNER.* *Observer.*	Construction of gauge.	Maker's name.	Time of reading.	Height of gauge. Above ground.		Above sea-level.
	1874.					ft.	in.	feet.
535.	Aug. 1.	DORSETSHIRE. Upwey. *J. MILLER, ESQ.* *J. Miller, Esq.*	III.	Casella	9 a.m.	1	3	70
536.	Aug. 3.	DORSETSHIRE. Osmington Lodge, Weymouth. *MAJOR HALL.* *Major Hall.*	XII.	Casella	9 a.m.	1	0	270
537.	Aug. 3.	DORSETSHIRE. Abbotsbury. *EARL OF ILCHESTER.* *Mr. Dight.*	XII.	Casella	9 a.m.	3	0	140
538.	Aug. 4.	DORSETSHIRE. St. Andrew's Villas, Bridport. *A. STEPHENS, ESQ.* *A. Stephens, Esq.*	X.	Negretti & Zambra	9 a.m.	1	3	60
539.	Aug. 4.	DORSETSHIRE. Bridport. *A. STEPHENS, ESQ.* *Mr. H. Hoare.*	X.	Negretti & Zambra	9 a.m. 1st.	1	3	45
540.	Aug. 4.	DORSETSHIRE. Spring Cottage, Lyme Regis. *H. TUCKER, ESQ.* *H. Tucker, Esq.*	XI.	Negretti & Zambra	....	4	6	270
541.	Aug. 4.	DEVONSHIRE. Clevelands [Lyme Regis]. *E. L. AMES, ESQ.*	XI.	Negretti & Zambra	9 a.m.	1	0	463
542.	Aug. 4.	DEVONSHIRE. White Cliff Glen, Seaton. *T. F. A. BYLES, ESQ.* *T. F. A. Byles, Esq.*	XI.	Negretti & Zambra	10 a.m.	2	0	160
543.	Aug. 4.	DEVONSHIRE. Sidmount, Sidmouth. *DR. RADFORD.* *Dr. Radford.*	III.	Casella	9 a.m.	1	0	149
544.	Aug. 4.	DEVONSHIRE. Sidmount, Sidmouth. *DR. RADFORD.* *Dr. Radford.*	....	....	....	8	7	195
545.	Aug. 6.	DEVONSHIRE. Mount Tavy, Tavistock. *H. CLARK, ESQ.*	III.	Casella	....	1	3	316

RAIN-GAUGES (*continued*).

Diameters (that marked M=mean).	Equivalents of water.		Error at scale-point specified in previous column.	Azimuth and angular elevation of objects above mouth of rain-gauge.	Remarks on position &c.	Reference number.
	Scale-point.	Grains.				
in.	in.		in.			
4·98	·1	510	−·002	E. Thorn bush, 43°.	On lawn in rear of house; good position.	535.
5·03	·2	1010	−·003			
5·03	·3	1500	−·001			
5·00	·4	2000	−·002			
M 5·010	·5	2500	−·002			
5·00	·1	490	+·001	N.W. House, 25°.		536.
5·00	·2	980	+·003	N.W. Pear-tree, 27°.		
5·02	·3	1500	−·002			
5·00	·4	1980	+·001			
M 5·005	·5	2450	+·007			
4·98	·1	490	+·001	S.E. Oak and mulberry, 42°.	Gauge to be moved 40 ft. N., when all will be under 20°.	537.
5·02	·2	broken.				
4·99						
5·01						
M 5·000						
8·02	·1	1210	+·004	E. Elms, 52°.	Position not good, but no better available.	538.
7·98	·2	2510	+·002	N.W. House, 42°.		
7·98	·3	3740	+·005	N.E. Elms, 30°.		
7·99	·4	5090	−·002			
M 7·993	·5	6340	correct.			
8·00	·1	1270	correct.	....	Very good position in field; kept as a check on 538.	539.
8·00	·2	2570	−·003			
8·00	·3	3770	+·003			
7·98	·4	5050	+·002			
M 7·995	·5	6350	−·001			
4·98	·1	500	−·001	S.W. Trees, 38°.	On N.E. slope of hill, at side of road. Position not good, but no better on the premises.	540.
4·99	·2	1000	−·002			
5·01	·3	1470	+·003			
5·00	·4	1980	correct.			
M 4·995	·5	2480	−·001			
5·00	·1	475	+·004	E.N.E. Pear, 33°.	Very good position in kitchen-garden.	541.
5·01	·2	940	+·011	N.N.W. Tree, 44°.		
5·02	·3	1450	+·008			
5·00	·4	1950	+·008			
M 5·007	·5	2465	+·004			
5·02	·1	460	+·007	S. Hill, 32°.	On a rapid slope, in the best position available.	542.
4·98	·2	950	+·009			
5·02	·3	1450	+·008			
5·00	·4	1940	+·009			
M 5·005	·5	2440	+·009			
5·03	·1	490	+·001	S.E. & S.W. Elms 40°.	On lawn; open, except as noted.	543.
4·98	·2	980	+·002			
4·95	·3	1480	+·001			
5·01	·4	1970	+·002			
M 4·993	·5	2460	+·002			
5·02	·1	490	+·002	S.E. Elms, 20°.	Very good position.	544.
5·01	·2	980	+·003			
5·00	·3	1470	+·005			
5·01	·4	1960	+·006			
M 5·010						
5·00	·1	500	−·001	N. Beech, 72°.	Gauge to be moved 40 ft. S., where tree = 40°, and all else clear.	545.
4·99	·2	990	correct.			
5·00	·3	1490	−·001			
4·99	·4	1980	correct.			
M 4·995	·5	2470	+·001			

EXAMINATION OF

Reference number.	Date of examination.	COUNTY. Station. *OWNER.* *Observer.*	Construction of gauge.	Maker's name.	Time of reading.	Height of gauge. Above ground.	Height of gauge. Above sea-level.
	1874.					ft. in.	feet.
546.	Aug. 6.	DEVONSHIRE. Rundlestone, Dartmoor. *G. J. SYMONS, ESQ.*	XII.	Casella	....	1 0	1450
547.	Aug. 6.	DEVONSHIRE. Prison Garden, Dartmoor. *G. J. SYMONS, ESQ.* *R. E. Power, Esq., M.D.*	XII.	Casella	9 a.m.	0 10	1381
548.	Aug. 6.	DEVONSHIRE. Kilworthy Hill, Tavistock. *W. MERRIFIELD, ESQ.* *W. Merrifield, Esq.*	XII.	Casella	9 a.m.	0 8	362
549.	Aug. 7.	DEVONSHIRE. Oaklands, Okehampton. *W. H. HOLLEY, ESQ.* *W. H. Holley, Esq.*	XII.	Casella	9 a.m.	1 0	521
550.	Aug. 7.	DEVONSHIRE. Lit. and Sci. Instit., Barnstaple. *LIT. AND SCI. INSTITUTION.* *Mr. Knill.*	X.	Negretti & Zambra	9 a.m.	0 8	31
551.	Aug. 8.	DEVONSHIRE. Northam, Bideford. *REV. J. D. CHURCHWARD.* *Rev. J. D. Churchward.*	XII.	Casella	9 a.m.	1 1	173
552.	Aug. 8.	DEVONSHIRE. Horwood, Bideford. *REV. J. DENE.* *Rev. J. Dene.*	III.	Pastorelli	9 a.m.	1 0	304
553.	Aug. 8.	DEVONSHIRE. Great Torrington. *REV. S. BUCKLAND.* *Rev. S. Buckland.*	XII.	Apps	Noon.	1 0	330
554.	Aug. 8.	DEVONSHIRE. Langtree Wick (daily). *MISS NUNES.* *Miss Nunes.*	XII.	Pastorelli	9 a.m. daily.	1 0	451
555.	Aug. 8.	DEVONSHIRE. Langtree Wick (monthly). *MISS NUNES.* *Miss Nunes.*	XII.	Casella	....	1 0	451
556.	Aug. 10.	SOMERSET. Gay Street, Bath. *C. S. BARTER, ESQ., M.B.* *C. S. Barter, Esq., M.B.*	XI.	....	9 a.m.	1 3	....

RAIN-GAUGES (*continued*).

Diameters (that marked M=mean).	Equiualents of water. Scale-point.	Equiualents of water. Grains.	Error at scale-point specified in previous column.	Azimuth and angular elevation of objects above mouth of rain-gauge.	Remarks on position &c.	Reference number.
in.	in.		in.			
....	....	....	....	S.E. House, 30°.	Gauge removed; site very good, in small garden.	546.
5·00	·1	490	+·001	....	In garden, quite open; good position.	547.
5·00	·2	975	+·003			
5·00	·3	1470	+·003			
4·99	·4	1975	+·001			
M 4·998	·5	2460	+·003			
5·01	·1	500	−·001	N.N.W. Wall and trees, 35°.	In small garden; clear, except as noted.	548.
5·00	·2	990	correct.			
5·00	·3	1480	+·002			
5·00	·4	1950	+·007			
M 5·002	·5	2490	−·002			
5·02	·1	490	+·001	....	Excellent position in very large garden.	549.
4·98	·2	970	+·005			
5·00	·3	1470	+·004			
5·02	·4	1960	+·005			
M 5·005	·5	2470	+·003			
8·00	·1	1270	correct.	S. Pear, 44°.	In small garden, and rather too sheltered.	550.
8·00	·2	2500	+·003			
7·98	·3	3760	+·004			
8·01	·4	5050	+·002			
M 7·998	·5	6300	+·003			
5·00	·1	500	−·001	....	Quite clear, in large level garden, near the church.	551.
5·00	·2	990	core ct.			
4·98	·3	1490	−·001			
5·00	·4	1980	correct.			
M 4·995	·5	2480	−·001			
5·01	·1	490	+·001	N. Firs, 52°.	On edge of lawn. Position good, ground nearly level.	552.
5·00	·2	980	+·002	S.W. Tree, 28°.		
5·00	·3	1490	−·001			
4·99						
M 5·000						
4·98	·1	500	correct.	S.S.E. Trees, 40°.	On lawn in Rectory garden.	553.
5·04	·2	995	+·001	N. Trees, 28°.		
5·01	·3	1450	+·009			
5·03	·4	1960	+·007			
M 5·015	·5	2455	+·008			
5·01	·1	475	+·004	....	Good position in large garden.	554.
5·00	·2	980	+·003			
5·01	·3	1480	+·002			
5·00	·4	1970	+·003			
M 5·005	·5	2460	+·005			
4·98	·1	475	+·004	....	Close to No. 554.	555.
5·00	·2	980	+·002			
5·02	·3	1480	+·001			
4·97	·4	1970	+·002			
M 4·993	·5	2460	+·002			
4·95	·1	490	+·001	E. House, 32°.	Position not good, but no better available.	556.
4·85	·2	980	+·002	W. Tree, 35°.		
4·95	·3	1480	+·001			
4·84	·4	1950	+·006			
M 4·898	·5	2440	+·006			

On the Belfast Harbour. By T. R. Salmond, *C.E.*

[A communication ordered by the General Committee to be printed *in extenso.*]

(Plates I.-III.)

It is with no small degree of diffidence that I have undertaken to draw up an account of the Port and Harbour of Belfast, the subject being one of considerable importance, and the materials at my disposal somewhat meagre, at least so far as the ancient history of the harbour is concerned. I have, however, endeavoured to prepare, in as concise a manner as possible, a synopsis of the various improvements which have been effected in the harbour, at least so far back as the sixteenth century; prior to which time the position of Belfast as a seaport or place of resort for shipping was rather vague and indefinite, if we can judge from the fact that no mention whatever is made of its existence as a harbour in any historical record prior to that date. On examination of the map of Belfast (*vide* Plate I.) which was prepared as early as 1660 (perhaps one of the most ancient maps of the town now extant), it will be seen that the old town was, as compared with Belfast of the present, a very insignificant place indeed. The limits of the town were circumscribed by an extensive line of fortification, which encompassed it on the north, south, and western sides only, it being bounded on the east side by the river Lagan, the land entrances to the town being by two gates called the North Gate and the Mill Gate. The North Gate was situated in North Street, at its juncture with John Street, and the Mill Gate was situated in Mill Street, at a point about 330 yards from the entrance to the Old Castle. It would, then, appear that the ramparts of the town ceased at William Street and commenced at Mary Street, now called Corporation Street, the interval between these points being bounded by the Lagan river precluded the chance of land attack from the eastward side of the town. At this time Belfast only consisted of five streets—High Street, Bridge Street, Skipper's Lane, Waring Street, and North Street; and the number of houses then in existence were, exclusive of the Castle, 150, the greater number of which were thatched houses of an inferior class.

Previous to the year 1637 the harbour appears to have been under no regular system of government, and was assumed to be the property of the Chichester family. The trade was at that time as insignificant as the harbour itself, which was, in point of fact, a port of secondary importance to Carrickfergus, which was the only stronghold in the bay occupying the same position relative to the latter town that Carlingford did in respect to Newry. Prior to the date I have just mentioned, the Corporation of Carrickfergus enjoyed the privilege of reserving to their use one third of all the Customs duties payable on goods imported into that place, together with other trading monopolies. These immunities, however, the Earl of Strafford succeeded in purchasing in 1637, since which time the commerce of this port has become a matter of importance. A Custom House was then for the first time established in Belfast, and the revenue business of the port removed from Carrickfergus. In the year 1729 the first legislative interference with the port took place, when an Act, 3rd George II., was passed, which delegated to the Sovereign and free burgesses of the town the conservancy of the harbour. The Corporation of Belfast had the harbour-trust committed to their care, and the reason assigned for appointing them as the conservancy was that, as expressed in the Act, "The harbour had become extremely shallow, by which means voyages have been prolonged, to the very great prejudice of

trade, and His Majesty put to extraordinary expense and charge in keeping officers longer on board the vessels trading to and from the said town than would be needful had the said harbour and channel been preserved in the same condition as it formerly was." This Act was, however, repealed in 1785 by the Act 25th George III. cap. 64, which appointed a separate Corporation, giving to them the sole management of the affairs of the port; and with the appointment of the Harbour Commissioners as a distinct body, the substantial improvements of the port may be said to have commenced.

Among the first acts performed by the new Corporation were the removal of several artificial fords, which formed bars across the Lagan, and also the gradual deepening of the bed of the river by dredging; and in 1786 the course of the old south channel was ordered to be marked with buoys and perches down to the Pool of Garmoyle.

In the year 1791 a graving-platform was erected for the repairing of small craft; and subsequently two graving or dry docks, which are at present in existence, were constructed, the first of which (No. 1) was completed and opened in the year 1800, and the second, now called No. 2 Dock, was opened in the year 1826.

These docks are situated on the south-west side of Clarendon Dock, and are found to be of great service for the repairing of vessels of small draft and tonnage. Their general dimensions are as follow:—

Dock No. 1.

	ft.	in.
Length on floor	245	0
Length at top	252	6
Breadth at top	50	0
Breadth at bottom	35	6
Level of sill above datum	1	9
Depth of dock from coping to floor	14	0
Width of entrance	30	0

Dock No. 2.

	ft.	in.
Length on floor	287	0
Length at top	299	0
Breadth at top	58	0
Breadth at bottom	34	0
Level of sill	datum	
(which is 3 ft. above the Ordnance datum)		
Depth of dock	15	6
Width of entrance	36	0

In the year 1826 Mr. John Rennie reported upon the state of the harbour with a view to its being extended and improved, and in the year 1829 Mr. Telford reported for a similar purpose. Mr. Rennie again reported in 1829. No action, however, was taken on either of these reports, and the improvement of the harbour was consequently delayed until a report and plan had been received from Messrs. Walker and Burgess in the year 1830, which plan was adopted by the Commissioners, and received the royal assent in the year 1831. Obstacles were, however, thrown in the way of procuring the necessary funds to carry out the work, and the result was an application to Parliament, in the year 1837, for a new Act, 1st Vic. cap. 76, which was acceded to; and the works directed to be undertaken in connexion therewith were:—

1st. The making of a new channel for the river Lagan, from Dunbar's Dock to Thompson's Tower, cutting off the first bend of the old channel nearest the town.

2nd. The purchase of the existing quays and docks, which were private property, and the widening and improving of the same.

3rd. The continuation of the straight cut for the river as far as deep water, cutting off the second bend of the river, so as to form a straight channel from the town towards Garmoyle, and other works contemplated by the Act.

The first of the foregoing works, being the first section of the new channel, was undertaken by Mr. Dargan, the contractor, and was completed and opened in the year 1841, the cutting of the channel forming a very valuable property called the Queen's Island, which contained an area of seventeen acres of land. The entire cost of this work, including the purchase of property, amounted to £42,352.

In the year 1842 the whole quays and wharves on both sides of the river, together with Dunbar's dock (now called Prince's Dock), quays, timber-pond, and nineteen acres of ground, the site for future docks, were all purchased at a sum amounting to £152,171; and a sum of nearly £1000 was expended in the improvement and permanent repair of Prince's Dock, the walls of which were composed of timber and brickwork.

In the year 1844 the construction of new quays was commenced on the county Down side of the harbour for a length of 2500 feet—about 500 feet, next the Queen's Bridge, being in front of an old wharf purchased from Mr. Batt, and the remaining portion on the slob land lying between it and the Queen's Island. This work was called the Queen's Quay, in the construction of which was expended the sum of £31,167. It is composed of a facing of timber securely tied back by three rows of strong piles, which are connected together with tie-rods of iron $1\frac{1}{2}$ inch in diameter; the main piles are 12 in. by 12 in., and the sheeting-piles are 7 inches in thickness, driven to a batter of 1 inch to a foot. The quay being formed, a landing-shed was erected on it, 300 feet in length. The material used for filling in or backing up the quay was mainly procured by the deepening of the river, which was also considerably widened in front, a quantity amounting to about 524,175 tons of material being deposited in forming the quays.

Among other works carried out at this time were a large pond for the storage of timber on the east side of the Queen's Island, formed at a cost of £1878; and the lighthouse, erected on piles, which is situated on the Holywood Bank, and which is used as a pilot station, was constructed at a cost of £1300.

Having in the year 1844 secured possession of the old quays and other property on the county Antrim side of the river, the construction of new quays on that side was immediately proceeded with. The total length of quayage erected at that time was 1375 feet, of which 713 feet was an increase, the remainder being the restoration of a portion of the old work. These quays were formed of timber, and were carried out on the same plan as that adopted for the Queen's Quay.

The total monies expended previous to the year 1847 on the various works embraced in the Act of 1837, including the construction of the Holywood Bank Light Station, amounted to £238,740.

In November 1846 a contract was entered into with Mr. William Dargan for forming the second section of the new channel, which was completed and formally opened in the year 1849, when it received the title of Victoria

Channel. This, the second portion of the channel executed, lies between the Twin Islands, which were formed by the material excavated from the bed of the second cut, and cast up so as to form a sea-slope of about 4 feet horizontal to 1 foot vertical, the channel faces of which slope were protected by a heavy facing of stone-pitching. The length of this cut is about 3300 feet, the width at top being about 450 feet, with a depth of about 23 feet at high water, and the amount expended in its formation was £41,000.

The next work of importance which was proceeded with was the rebuilding of the county Antrim quays from the Queen's Bridge to Dunbar's or Prince's Dock, and their extension, or the formation of new quays, from that point to the Milewater River, the latter portion being commenced and completed in the year 1847—the entire quays being handed over by the contractor, Mr. Cranston Gregg, complete during the year 1848, their cost being about £44,390. This work is composed of timber facing, similar to that adopted on the Queen's Quay, and the entire designed with a view to having about 10 feet of water close to the quay at low tide.

In the year 1847 the construction of a patent slip was commenced on the south end of the Queen's Island. This slip is 560 feet in length, and was designed so as to be capable of taking on vessels of 1000 tons burthen. It is worked by a twenty horse-power steam-engine, with hauling machinery. The cost of the entire work in connexion with the slip was about £16,753. The work was completed and opened for traffic early in 1849. In the year 1847, owing to improvements then in contemplation and in course of progress, it became necessary to procure a new steam-dredger in addition to the one then in the Commissioners' possession. The new machine was constructed in that year by Messrs. Coates and Young, and was provided with a twenty horse-power engine; the cost of the new machine was £5260. The way in which the dredgers were principally employed at this time was in deepening of the river between the new wharves, and the material raised was used for filling up the spaces between the old and new Ballymacarrett quays, filling up the old town dock at the foot of High Street, and other old docks on the county Antrim side of the harbour, and in backing up the new quay of the first cut of the channel, now called Albert Quay.

In the year 1847 a second timber-pond was constructed on the county Antrim side of the river, and is situated convenient to Prince's Dock and Albert Quay. This pond was made by Mr. Dargan in a field adjoining the old pond, about 20,000 cubic yards of stuff being removed in its formation.

The only additional works worthy of notice which were undertaken in the year 1848 were the erection of a stone beacon on the tail of the west bank at Garmoyle, at a cost of £218, and the construction of a wrought-iron swing-bridge to span the entrance to the then Graving-Dock Basin, at a cost of about £1351. These works were completed during the year 1849.

In the year 1849, in order to meet the growing requirements of a very important class of shipping, such as the moderate-sized vessels carrying valuable cargoes from the Mediterranean and Baltic ports, it was determined to extend the basin in front of the graving-docks. This work was proceeded with, the basin being extended in a southward direction so as to form a dock, which in 1850 was designated the Clarendon Dock. In the same year, 1849, the old tidal docks, situated at the foot of Waring Street and Great George's Street, were filled up, and the spaces occupied by them thrown open to the public.

Prior to the commencement of the improvements embraced in the Act of 1837, the cost of dredging had always formed a large item in the annual

expenditure of the Belfast Harbour. This had, however, considerably increased during the four or five years just preceding the year 1849—as, in addition to maintaining the original depth, the course of the river opposite what was then called Ritchie's Dock was diverted from its natural channel by the extension of the quays, and the entire space from the Queen's Bridge to the Prince's Dock doubled in width, the depth of the water being at the same time increased 5 to 7 feet.

It was anticipated that the formation of the straight channel would obviate the necessity of so much dredging as hitherto in the lower part of the river; and the fact that the upper section of it maintained its depth without dredging from its opening in 1841 for a period of nine or ten years, confirms this view. The increased depth, however, given to the river opposite the quays, being much below its natural bed, will always require an additional amount of dredging to prevent it from silting up, which would, of course, vary and increase in extent as the sewerage of the town increases, if allowed to be discharged into the harbour.

In the year 1850 the only works worthy of notice which were entered upon were the erection of coal-offices, yards, and weighing-machines on Queen's Quay, and six landing- or goods-sheds on Donegall Quay, and contracts for the erection of a stone wall on the north side of the Clarendon Dock.

In the year 1851 three lighthouses were constructed in the Channel, between Garmoyle and the town of Belfast, and provided with accommodation for resident lightkeepers in order to supersede the difficult and uncertain plan previously resorted to, *i.e.* of attending to the Channel lights (which were fixed upon perches) by means of a boat. One of the houses, a substantial stone structure, is situated on the lower end of the East Twin Island, and provided with a bright green light; one on the margin of the old Seal Channel, provided with a red light; and the other at the Pool of Garmoyle below the stone beacon and on the opposite side of the Channel, which is provided with a green light. The two latter lighthouses are constructed on the borders of the slob banks, and are composed of timber supported upon strong piles, braced with wrought-iron tie-rods, the cost of the three houses being about £741.

In the year 1852 an iron foot-bridge was constructed across the entrance to the Prince's Dock at a cost of £309, and a timber bridge across the entrance to the Milewater River, thereby opening up an uninterrupted traffic for foot passengers from the Queen's Bridge to Thompson's embankment.

In the year 1854 a new Harbour Office was erected at the foot of Great George's Street, at a cost of £8306; and the only other new works carried on in that year were the construction of a branch line of railway, commencing at the main line, a short distance from the terminus of the Northern Counties Railway, running along the reclaimed ground purchased from Mr. Thompson, and connected with the Albert Quay; and a new street called Whitla Street, running from the north end of Garmoyle Street to York Street, opening up a connexion between the quays and the railway.

The Harbour Commissioners having in the year 1854 obtained a Bill empowering them to reclaim a large portion of the slob lands lying on the county Down side of the river, consequently in the following year a commencement was made upon that work, Mr. James Connor being appointed contractor for the execution of a bank extending from the Queen's Island to Conswater Railway Bridge. This work was completed in 1858. This portion of the reclamation included the part to be devoted to the purposes of a public park, to be called Victoria Park.

In the year 1858 a commencement was made towards the regular deepening of the navigable channel from the Holywood Lighthouse to the upper end of Donegall Quay. The improvement made by the dredging, which continued from 1858 to 1861, was such that vessels with a deep draft of water were enabled to get up to the lower end of the Victoria Channel without lightening their cargoes, as they had hitherto done, two miles lower down the river, in order to enable them to take a berth at the quays or to enter the docks; and steamboats were also enabled to reach their berths at all times of the tide. The next works of magnitude which were undertaken by the Belfast Harbour Commissioners were commenced in the year 1864, and consisted of the construction of a floating dock and tidal dock on the county Antrim side of the harbour, and a graving or dry dock and tidal basin on the county Down side of the harbour. These may be said to be the first really important works, apart from the deepening of the harbour, which were undertaken since the year 1847.

Unlike the previous mode of constructing the wharves with timber, the Commissioners were advised in these cases to resort to the use of stone as a building material. On the county Antrim side of the harbour, where the ground for foundations is of such a treacherous nature, the entire works had to be built upon bearing or supporting piles. On the top of the piles a layer of concrete two feet in depth was laid, on which the superstructure was raised. The walls are generally of the section shown on the contract drawing, and are built of rubble stonework, faced with random rubble. On the county Down side of the river, the nature of the soil being firm hard sand, no artificial foundation was necessary. On both sides, however, the precaution has been adopted of driving a row of sheet piles, 6 inches thick, along the face of the work, to preclude the chance of the foundations being undermined by dredging or other causes.

These dock works, though commenced in the year 1864, were not all completed till the year 1871. The Hamilton Graving-Dock and Abercorn Basin were, however, finished and formally opened by the Lord Lieutenant in the year 1867.

The Abercorn Basin is 725 feet in length by 635 feet in breadth, having a water-area of $12\frac{1}{2}$ acres. The average depth of water in that basin is now about 11 feet at low water, and a canting space secured in the harbour which will allow a vessel of 600 feet in length to turn upon its own centre as a pivot. The cost of this basin was £23,163.

The Hamilton Graving-Dock is in length at top 470 feet, and at bottom $451\frac{1}{2}$ feet. It is 84 feet 6 inches broad at coping, and 50 feet broad at bottom. The coping is 15 feet above datum, and the level of sill at entrance is 5·60 feet below datum. The entrance of the dock is 60 feet in width, and the depth of the dock is 22 feet 9 inches below coping. It is provided with a caisson gate, which can be used as a bridge or road for horse-and-cart traffic when set in place. A powerful engine and centrifugal pump, with pumping machinery, is provided for clearing the dock of water when requisite for repairing vessels. The cost of this graving-dock, including mooring-paals, paving, gas- and water-pipes, capstans, paals, &c., amounted to £33,756. Of this, £2376 was expended on the caisson; and a further sum of £5140, not included in the above, was expended on the engine and pumping machinery and buildings in connexion therewith.

The works on the county Antrim side, comprising the Spencer Dock, Dufferin Dock, and entrance-basin, were formally opened by Earl Spencer, Lord Lieutenant of Ireland, in the year 1872. The Spencer Dock is a tidal

dock, 600 feet long by 550 feet broad, having a water-area of $7\frac{1}{2}$ acres, and a quayage in length 1900 feet. The average depth of water in this dock is 14 feet below datum, and the coping is 15·6 feet above datum. The entrance to the dock is 80 feet in width by 265 feet in length. The entrance-basin has an area of 5 acres of water, with a quayage of 200 feet in length.

The Dufferin Dock is a floating dock, provided with gates, inside which vessels with a draught of 22 feet can discharge afloat at all times of the tide. The entrance to this dock is from the Spencer Dock, and is 60 feet in width by 139 feet in length. The platform for gates is 14 feet below datum, and the sill is 12 feet below datum. The dock is in length 630 feet by 225 feet in width, having a water-area of $3\frac{1}{4}$ acres and length of quayage of 1645 feet.

The walls of these works are all constructed of stone, the lower portion of the dock from bottom up to datum-level being composed of hammerstone ashlar, the stone being from the Scrabo quarries, county Down; and the portion above datum is composed of freestone hearting, with facing of Dundonald whinstone, the coping being of Cornish limestone in large blocks. The cost of these works amounted to £95,334, including gates, mooring-paals, chains, paving, &c. Simultaneously with the execution of these works, other incidental works, though of minor importance, were being carried on. The Milewater River was diverted into a new channel, and two extensive timber-ponds, one of 5 acres and the other of 14 acres, formed on the Antrim side of the harbour, chiefly by the excavations from the dock works. The branch railway was diverted along Albert Quay, and a permanent line of tramway laid connecting it with the Northern Counties Railway.

The slob reclamation in county Down was being proceeded with from year to year; and in 1864 a carriage-road bridge was constructed across Connswater to connect the Victoria Park with the Ballymacarrett reclaimed property, at a cost of £652.

In 1867 a double line of tramway was laid along the south side of the Abercorn Basin, and connected with the county Down Railway. A number of goods-sheds were erected along the quays from time to time, and dock-master's houses and other tenements, as required by the extension of the harbour; and in the year 1871 a large pair of masting-sheers were erected on the east side of Abercorn Quay, capable of lifting a weight of 50 tons and masting the largest vessels afloat; the cost of these sheers amounted to £2732, including foundations, engine-house, &c. In the same year (1871) a line of tramway, commencing at the junction of the Central Railway at Oxford Street and extending along the Antrim quays around Prince's Dock, formed a junction with the Northern Counties branch of the quay's tramway at the south end of the Dufferin Dock. Owing to the extension of the harbour works, it became necessary in the year 1870 to provide for extensive dredging. A contract was therefore entered into for a new steam-dredger of 40 horse-power, capable of working in 26 feet of water, which was completed in the following year at a cost of £7923, and a large number of new scows were constructed in connexion with this machine. In the year 1872 an inclined discharging-slip was constructed at the lower end of the Queen's Island, and provided with a hauling-engine and gearing for the purpose of disposing of the dredging-material in the embanking of the county Down reclaimed lands; and for the transit of the stuff a locomotive engine and stock of tipping-waggons were provided, by which means the material can be both cheaply and expeditiously transported to any part of the county Down

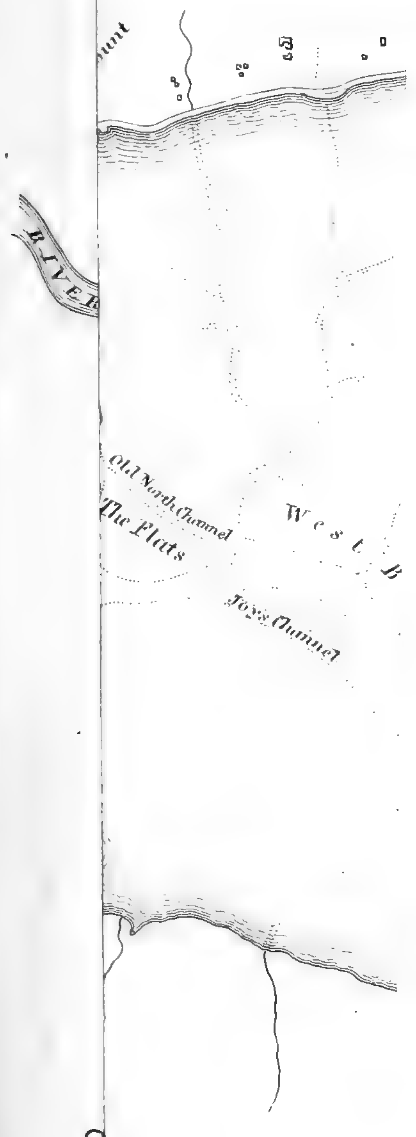
property. In the same year, the Commissioners having secured by purchase from Dr. Ritchie a large tract of slob land on the county Antrim side of the channel north of Thompson's embankment, a commencement was made with its reclamation from the sea. This work is still in course of progress, and when reclaimed will afford a valuable parcel of ground for harbour extension, 95 acres in area. The embankment is being entirely formed of material raised by the dredgers in deepening the harbour. The slope is formed on the outside, at an inclination of 4 to 1, and is being securely protected by stone-pitching. Having acquired the latter grounds, steps were at once taken to form a large portion of it into a timber-pond, which was done by enclosing an area of about 26 acres with a row of closely driven round larch-piles.

In the year 1872 a work of considerable magnitude was commenced, and is at the present time in course of progress; it consists of the renewal of the entire length of Albert Quay, and its further extension to the circular pier head of the Spencer Dock. A portion of this work for a length of 267 feet is constructed of stone, in the same manner as that in which the other stone-work of the docks is executed, the remainder being constructed of timber. The entire length of the work is about 680 yards, which will give, besides the renewal of the decayed portion of the Albert Quay, an additional length of quayage of 207 yards. The timber-wharf is about 1776 feet in length by 25 feet in width at the top, is composed of three rows of bearing-piles of creosoted pitch-pine timber, 12 inches square, the front row being 48 feet in length, the middle row 43 feet, and the back row 40 feet. These piles are driven 5 feet apart, centres longitudinally, and between the piles in the front and mid row sheeting-piles of the same timber 11 inches in thickness are driven quite close together, the length of the front row being 37 feet, and that of the middle row 32 feet. The front and back rows of main piles are secured together by diagonal braces. The platform is composed of strong joists 12 inches by 6 inches, sheeted with timber planking $5\frac{1}{2}$ inches thick, which is covered with a layer of bitumen, and paved with square setts. The back of the wharf is sheeted with timber 4 inches in thickness, against which is filled a backing of engine ashes and cinders, in order to secure the least possible lateral thrust against the wharf. The space underneath the wharf, between the front and back row of piles, is formed into a slight slope, which is paved with pitching-stones, in order to prevent the abrasion of the water from carrying away the soil; and the front face of the wharf is *cleaded* with open timber work to prevent the deposit and accumulation on the slopes of bulky matters held in suspension by the water. Mooring-piles of egreenheart timber, cuppd with cast-iron hoods, are driven every 60 feet apart along the entire wharf to secure vessels to; and a number of sets of strong piles are driven 60 feet back from the wharf, and are connected with it by strong tie-rods of wrought iron, in order to guard against the possibility of the wharf being driven forward by any undue weight placed on the platform, or by the weight of the materials by which it is backed up. The piling of this work is so designed that a depth of 16 feet at low water may be secured by dredging without the risk of injuring the stability of the superstructure, and by the setting back of the quay line as it is done a water space of about 335 feet in width will be provided in the river opposite the new wharf. This work is being carried on by Messrs. H. and J. Martin, contractors, and will, when completed, cost about £50,000. During the present year an extensive double line of tramway has been laid by the Harbour Commissioners from the South Quay of the Abercorn Basin through

their property in Ballymacarrett, and connected with the Central Railway near the point where it crosses the county Down line. This tramway completes a system which opens up a thorough line of communication between the county Antrim and county Down sides of the river, and affords a valuable means of transit of goods by rail from almost all quays in the harbour to the County Down, Central, Ulster, and Northern Counties Railways. In order to meet the rapidly increasing requirements of the trade of Belfast for additional dock and harbour accommodation, I lately received instructions from the Commissioners to prepare plans and specifications for works of considerable magnitude proposed to be carried out on the county Antrim side of the harbour. The plans which I submitted were approved of by the Commissioners. They consist of a large wet dock 1200 feet in length, exclusive of the entrance, and 280 feet in width, with a depth of 20 feet at low water. This dock it is proposed to extend, when the trade of the port shall have increased to such an extent as to warrant it, from where it is at present shown to terminate to the foot of Corporation Square, an additional distance of about 1250 feet, which would close the Clarendon Dock, and do away with the two old graving-docks situate off that dock. The entire length of the dock when completed would be 2450 feet, giving a water-area of about $15\frac{3}{4}$ acres, with two entrances, one where the present entrance to Prince's Dock is situated, and one entering from the Spencer Dock; and I may just state that my reasons for recommending an open wet dock in preference to a dock closed by gates are, that the moderate range of tide which exists in this harbour being only 8 feet average, together with the improved modern mechanical appliances for loading and discharging vessels, renders the rise and fall of a few feet of tide an immaterial question either as regards time or money; and further, that with an open dock vessels will not require, as they would with a close dock, to accumulate opposite the entrance to such an extent as to impede the general traffic in the outer or Spencer Dock, a free and open means of communication being maintained with the river, so that vessels can arrive and depart at all times of the tide. The gates and sluices of a close dock are also liable to derangement or accident, and tend under any circumstances more or less to limit the amount of traffic to the dock.

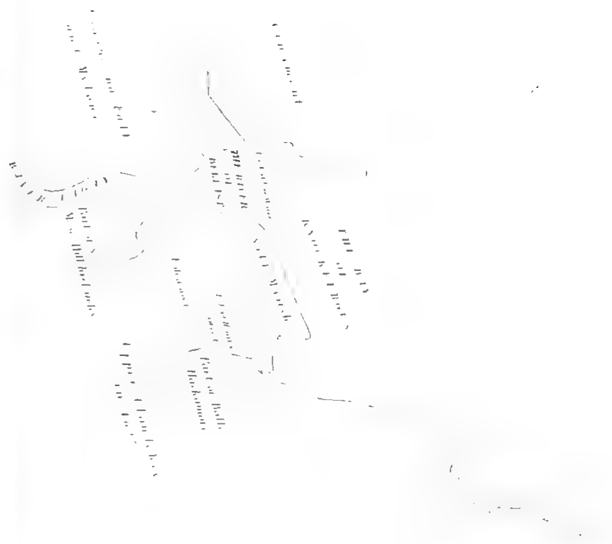
It is also proposed, in order to meet the demand for additional graving-dock accommodation, to construct, on the county Antrim side of the river, a dock of about 600 feet in length, capable of receiving the largest vessels built in or frequenting this port.

Another extensive improvement, which has for some time occupied the attention of the Commissioners, is the formation of a new straight channel across the west bank, in continuation of the Victoria Channel, between the Twin Islands and Whitehouse Roads; and will, no doubt, when carried out, afford great facilities (as compared with the present circuitory route) for vessels either entering or leaving the port, and lessen the risk of danger and delay consequent upon vessels taking the ground on the slob banks lying on either side of the present channel. I have thought it might be interesting, and have therefore appended detailed information as to the areas, &c. of the property at present in possession of the Belfast Harbour Commissioners. The total area of property on both sides of the harbour is 1008 a. 2 r. 17 p.; of which 526 a. 1 r. 11 p. is on the county Antrim side, and 482 a. 1 r. 6 p. on the county Down side according to the original county boundary, 95 acres of the property on the county Antrim side being at present in course of reclamation. Of the above area about 470 acres have been reclaimed from



RIVER
Old North Channel
The Flats
West B
Joy's Channel

Plate 1



OF BELFAST

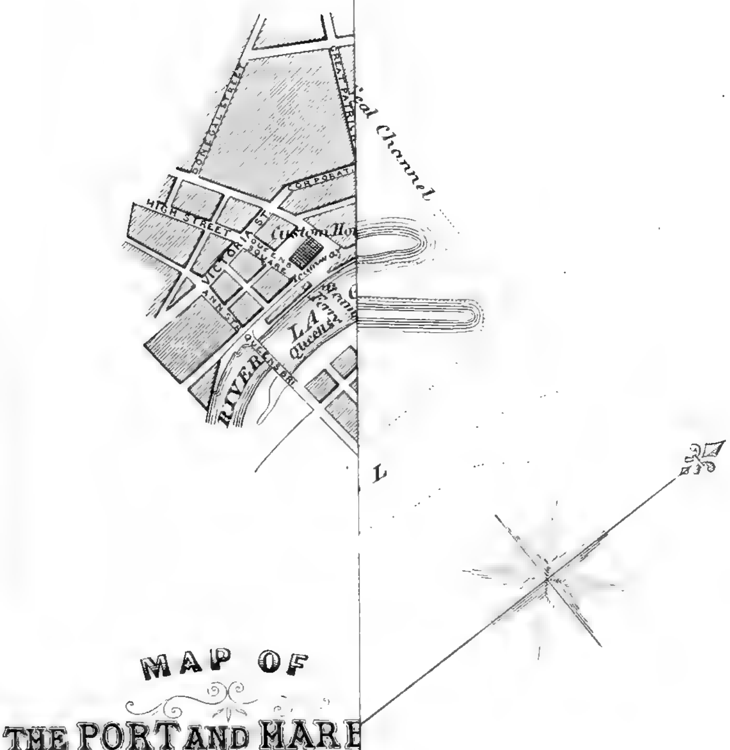
1660

MAP OF

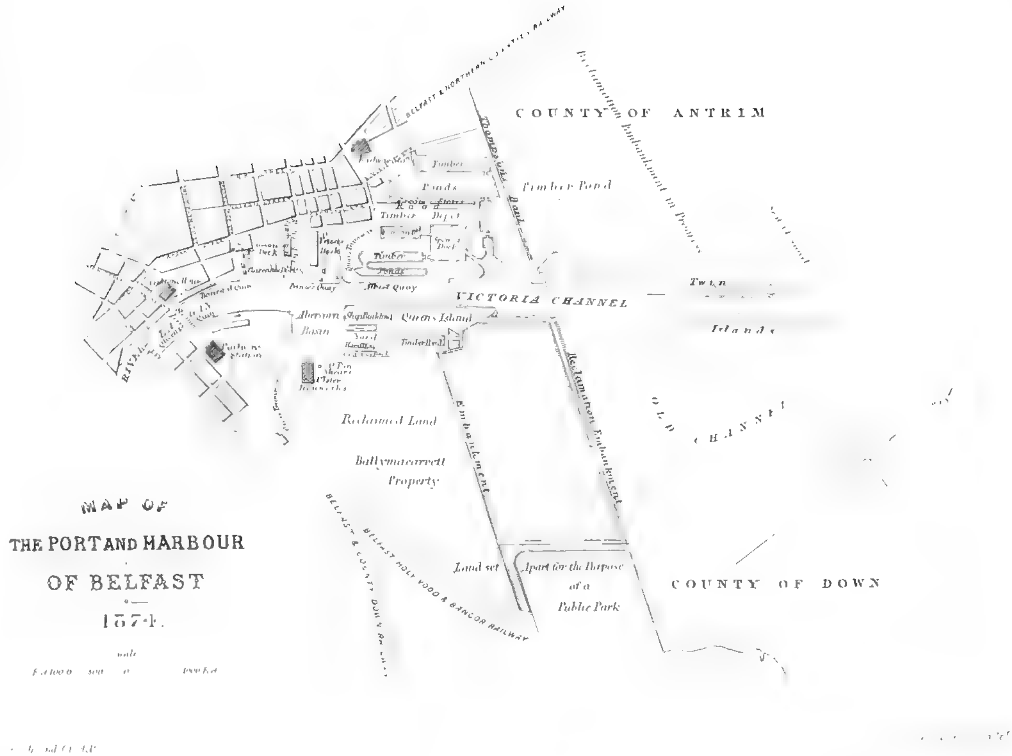
THE PORT AND HARBOUR

OF BELFAST

1840



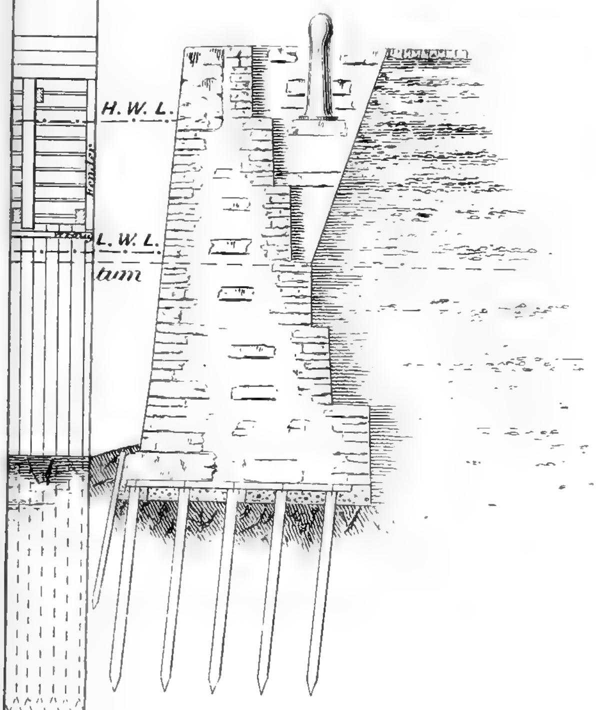
Thomas Rose Salmond, C.E. delt. Chas. Ingram Sculpt.

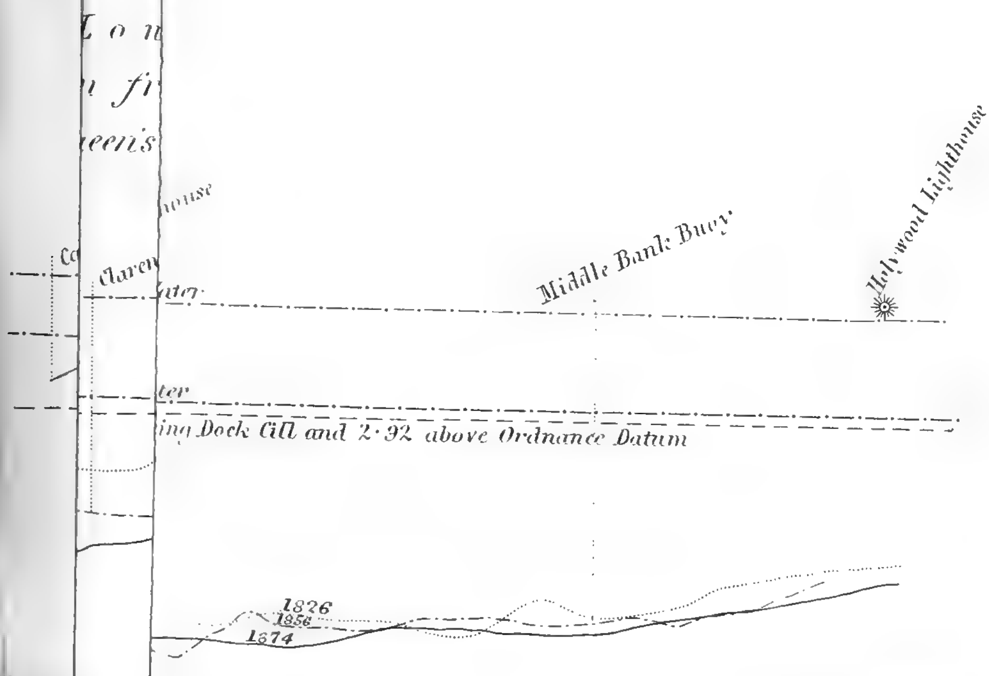


MAP OF
THE PORT AND HARBOUR
OF BELFAST
1874.
COUNTY OF ANTRIM
COUNTY OF DOWN
VICTORIA CHANNEL
BELFAST & NORTHERN COUNTIES RAILWAY
BELFAST HOLYWOOD & BANGOR RAILWAY
BELFAST & COUNTY DOWN RAILWAY
Timber Pond
Timber Ponds
Timber Depot
Queens Island
Abercorn Basin
Reclaimed Land
Ballymacarrett Property
Embankment
Reclamation Embankment
Twin Islands
OLD CHANNEL
Land set Apart for the Purpose of a Public Park

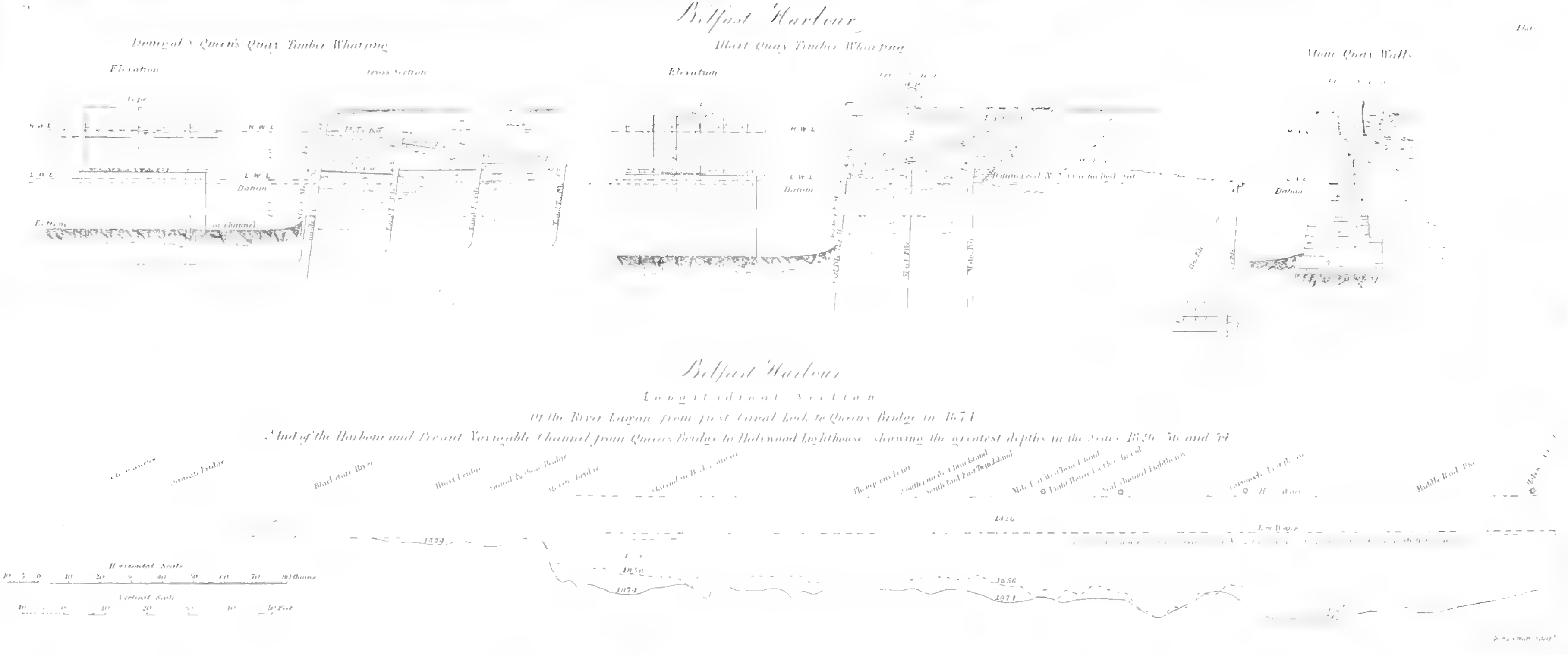
Stone Quay Walls

Cross Section





Chas. Ingram Sculpt.


Belfast Harbour
Elevation
Cross Section
Elevation
Stone Quay Walls
H.W.L.
L.W.L.
Datum
Belfast Harbour
Longitudinal Section
Of the River Lagan from first Canal Lock to Queens Bridge in 1874
And of the Harbour and Present Navigable Channel from Queens Bridge to Holywood Lighthouse showing the greatest depths in the Years 1826, '56 and '74
1826
1856
1874
Low Water
Horizontal Scale
Vertical Scale

the sea. The total water-area of the harbour, including docks and basins, amounts to about 100 acres; and the total length of available quayage 16,433 linear feet. The area of timber-ponds at present in existence is 64 a. 2 r. 20 p.

The total number of vessels which entered the Port last year was 7538, of an aggregate registered tonnage of 1,268,845 tons; and the revenue for the same year (1873) amounted to £69,681 8*s.* 7*d.*

The Plans illustrative of this paper are:—

Plate I. Map of Belfast in 1660, and Map of the Port and Harbour of Belfast in 1840.

Plate II. Map of the Port and Harbour of Belfast in 1874.

Plate III. Sheet of Sections of the Timber and Stone Quays; and a Longitudinal Section of the river Lagan from first Canal Lock to Queen's Bridge in 1874, and of the Harbour and present navigable channels from Queen's Bridge to Holywood Lighthouse, showing the greatest depths in the years 1826, 1856, and 1874.

Report of the Committee, consisting of W. Chandler Roberts, Dr. Mills, Dr. Boycott, A. W. Gadesden, and J. S. Sellon, *appointed for the purpose of inquiring into the Method of making Gold-assays, and of stating the Results thereof. Drawn up by* W. Chandler Roberts, *Secretary.*

In their last Report the Committee described the results of a series of experiments made with a view to determine the degree of accuracy to which it is possible to attain in gold-assaying. It was proved that the error was included between the $\frac{1}{10,000}$ and $\frac{2}{10,000}$ parts of the portion of metal operated upon. They recommended that a standard plate of pure gold, prepared by the Chemist of the Mint, should be adopted as a basis for a new series of comparisons between the reports of different assayers; but during the past year the Committee have rejected this plate in favour of a second, which proved to be of a sensibly higher degree of purity.

This new plate was submitted in December last to a jury of assayers, summoned by the Goldsmiths' Company, and their certificate as to its purity is published in the Report of the Deputy Master of the Mint for 1873, p. 58.

Portions of this plate have since been sent by the Warden of the Standards, to whom the custody of the trial plates is entrusted, to Mr. Du Bois of the United States Mint, to M. Péligot at Paris, to the Chevalier Van Riemsdijk of the Netherlands Mint, and to M. Stas at Brussels, as well as to the Assayers of the Mints at Sydney and Melbourne.

Only one Report has as yet been received, and the Committee therefore considered that they were not in a position to proceed further with the investigation before this Meeting of the British Association.

Report of a Committee, consisting of Prof. A. S. Herschel, *B.A., F.R.A.S., and* G. A. Lebour, *F.G.S., on Experiments to determine the Thermal Conductivities of certain Rocks, showing especially the Geological Aspects of the Investigation.*

Description and Results of the Experiments. By Prof. A. S. Herschel.

In the introductory notes on these experiments in the Transactions of the Sections, p. 223, in the volume for 1873 of these Reports, the list of rocks selected and the manner of experimenting on them were described. With the exception that sections of Calton trap-rock, of a great pyramid casing-stone (nummulitic limestone), Caenstone (or Normandy building-limestone), cannel-coal, chalk, and red brick were added to this list, and that the apparatus received some small but very important improvements to make it heat-tight, the material of the experiments, as well as the method of making them, remained substantially the same as last year. Instead of a conical tin vessel with 1 lb. of water, a cylindrical one holding $2\frac{1}{2}$ lbs., with an internal agitator and thermometer, was used as the cooler. The opposing surfaces of the heater and cooler are faced with velvet, and are each encircled by a caoutchouc collar, which projecting a little beyond them clasps the circular edge of the rock plate when it is placed between them; two small slits in each collar-edge allow the wires of a thermocouple to be introduced, touching the rock-surfaces while the rock is being heated. With the view of traversing the plate with the thermopile in different directions, the piece of stout palladium wire (about 18 gauge), used as the electromotive element between two iron wire terminations of a delicate reflecting galvanometer, was silver-soldered to the iron wires at its two ends, all the wires being first rolled thin and flat to some distance from the junctions. The scythe or scimitar-blade shape generally given to the wire in rolling it thin was advantageous in the construction, because instead of uniting the wires continuously in one straight length and folding the points of junction upon opposite sides of the rock (thus confining their range upon it to a single diameter or to one straight line), advantage of the curvature was taken to connect the wires by superposition, instead of by prolongation at their junctions, without overlying each other, into two flat ogee-arches or merry-thought-like blades, between which the rock is held as in a forceps. The unrolled parts of the wires are bound very firmly to a small square piece of wood, which acts as a handle to guide the points of the forceps to various parts of the rock-faces, while it keeps them securely in their places, and also allows the small elastic pressure of the wires to help to clasp the rock gently between the points of the thermoelectric pincette without assistance from the velvet covers. After thus inserting a rock section in the apparatus, protecting the rock and cooler from below with a stout wooden screen, and from loss or gain of heat in other directions by a suitably thick case of woollen stuff and a few bandages of similar materials, the rate of rise of temperature in the cooler, when agitated, was noted by the average number of seconds taken by a delicate thermometer contained in it to rise $\frac{1}{5}$° F. (one graduation on its stem), as soon as this rate of rise was found to have become sensibly constant. About twenty minutes were usually occupied in the beginning of an experiment with watching for a steady condition of the thermometer-readings; and ten or twelve minutes more were required to ensure it, and to obtain the average rate of their increase for the rock specimen under observation. The temperature-difference shown by the galvanometer at the same time at first rose rapidly to a

high maximum, and then descended very gradually to a fixed lower reading. The pincette was traversed to and fro over the rock-surfaces while the thermometer was being noted, and exhibited during these motions fluctuations answering to about one or two Fahrenheit degrees on either side of an average position; corrected for zero of the scale, and reduced by trials for this purpose between every two or three experiments to Fahrenheit degrees, the temperature-difference thus found, divided by the quantity of heat transmitted to the cooler per minute, gave the apparent thermal conductivity of the plate. The results, in Peclet's units, were scarcely more than one third of what Peclet and other earlier experimenters had obtained. It was obvious that instead of marking the temperature-difference between the two solid contact surfaces of the rock and velvet which they touched, the points of the thermoelectric forceps showed the temperature of the fluid air-bath in which those two surfaces are immersed. The extreme mobility of this fluid medium, enabling it to pass to and fro through the velvet between the plates of the heater and the cooler, while it equally insinuates itself between the rock-surface and the thermopile that can only enter into actual solid contact with each other (at least theoretically) at three points, controls the temperature of the metallic thermometer far more powerfully than the rock-face that it touches, and the real temperature-differences between the rock-faces are accordingly completely masked. It is very probable that if the velvet covers on the instrument are replaced by caoutchouc or soft wash-leather, the source of this error will be very much reduced; and although it is certain that the confronting rock and leather surfaces will never have actually the same temperature from the existence of a sensible quantity of resisting air between them (so that, as before, the thermopile will not mark the true rock-temperature-difference, but a mean between that difference and a similar difference for the leather-faces), yet the range of this error will be considerably smaller than in the experiments already made with velvet covers, whose loose texture makes air-currents the principal medium of heat-transmission through them. The comparative results now obtained are accordingly only subjoined with this Report as first approximations, from which the errors, anticipated last year as likely to arise from surface characters of the rock sections, are as yet far from having been satisfactorily removed.

To obtain the true rock-temperature-differences means were taken to cement the thermopile-points to the rock with plaster, which it would be desirable to adopt with as few samples as possible, on account of the tediousness of the process, and the injury from using them thus as standards of correction for the rest done to the beautifully worked surfaces of many of the plates. If the correction found to be required can be restricted by the mode of operating to a range of such small limits as to be applicable generally, without appreciable influence of the surface characters in making its occasional departures from a mean value very sensible, then the reduction-factor, found by absolute experiments with a few rocks of characteristically rough and smooth or polished surfaces giving the true temperature-difference for a given heat-flow from the apparent one shown by the thermocouple placed simply between the rock and leather faces, will be admissible (within the limits of error of the observations) to convert a list of apparent conductivities, as just supposed to be obtained, from a mere comparative table of relative conducting-powers to a table of absolute thermal conductivities, in which the errors of the values given will certainly not be greater than would in all probability have been committed had the direct method

of absolute measurement been applied separately to each specimen of the list instead of only to a few rocks which furnish data for calculating the absolute conductivities of the remainder. Circular disks of linen well wetted with plaster of Paris (mixed with a little glue or white of egg) were laid over the surfaces of two or three of the rocks, enclosing under them and against the rock the two points of the thermopile-pincette, which were also first dipped into plaster. When these had set quite hard under pressure, and were thoroughly dried by a gentle heat, they were placed in the apparatus, and a measurement of the absolute temperature-difference and accompanying heat-flow was thus obtained, affording the real conductivity and a means of comparing it with the apparent one found by similar observations of the same rock when no plaster was used, and when the points of the thermopile merely pressed against its surface. Thus the thermoelectric difference obtained with the wire couples merely touching the surfaces of white statuary-marble between velvet faces was 16°; while for the same heat-flow, when the arms of the thermopile were firmly plastered to the marble plate, the temperature-difference observed was only 6°·2*, being more than twice and a half as large a difference in the former as in the latter case. With whinstone the corresponding temperature-differences were 26° and 8°·5, in the proportion of very nearly 3 : 1. A similar experiment was made with cannel-coal, of which the conductivity is much less than those of the last mentioned rocks, the temperature-differences obtained being for the same heat-flow in the plain and plastered plate 53°·4 and 39°·7; in the proportion of only 1·37 : 1, a far smaller reduction than was observed in the two foregoing cases. Care is, however, necessary to introduce wet plaster under as well as over the points of the thermopile in cementing them to the rock, that air may be excluded and the junction may be solid—a precaution which was omitted in this case, and plaster without size was used, which in drying sometimes flakes off from the rock-surface, either entirely or in places, which may render an experiment, as that on cannel-coal may not impossibly have been from this cause, entirely valueless; yet this result presents itself, with many others met with in the investigation, as very well worth repetition, with fresh precautions and with new arrangements, to guard against the possibility of false conclusions.

Adopting for the present, as probably not far from the truth, a common reduction-factor of $2\frac{2}{3}$ as the proportion in which the recorded temperature-differences of the plain rock-surfaces between velvet faces exceeded the true temperature-differences of the surfaces of the rocks examined, and introducing some very small corrections for the thicknesses of the plates, the thermal capacity of the metal cooler, &c., which are all probably (as well as the allowance for heat-absorption in raising the temperature of the rock plates very slowly during the observations) really negligible in comparison with the uncertainty that attaches (except in one or two well-observed cases of absolutely measured temperature-differences of the rock-faces) to the great majority of the determinations from unknown peculiarities of surface-contact and heat-transfer where air surrounds the thermopile, the following Table gives the absolute thermal conductivities (in centimetre-gramme-second

* The heat-flow through the plate was actually greater in this latter than in the former case in the proportion of about 5 : 4, showing that the rough plaster-washed linen surface received and delivered heat to the velvet covers much more readily than the smoothly dressed surface of the stone; and the whole resistance was less in the former than in the latter case, although the rock plate itself had been made thicker. The same diminution of the total resistance occurred also in the experiment with plastered whinstone.

or absolute British-Association units) thus provisionally obtained, together with a few similar results (in the third column of the Table) found by Peclet, Forbes, and Sir William Thomson in rocks differing little in their description from those included in the present list:—

Provisional determinations of Thermal Conductivities of certain Rocks. First Experimental Results.

Description of rock.	Thermal conductivity (gramme-water-degree heat-units per sec., at 1° difference of the faces, through a centimetre-cube).		Earlier observations of conductivities of similar rocks.	
			Description of rock.	Observers.
Grey Aberdeen granite...	·00600			
Red Cornish serpentine...	·00483			
Calton trap-rock (first specimen).	·00520	·00266	Calton trap-rock	Forbes and Thomson.
Whinstone..................	·00312	·00169	Sand of experimental rock, Thermometer Garden.	Forbes and Thomson.
Kenton sandstone	·00489	·00689	Craigleith sandstone...	Forbes and Thomson.
Congleton "second grit" sandstone.	·00462			
Slate	·00392			
Alabaster	·00412			
Sicilian white statuary-marble.	·00559	·0097	Fine-grained grey marble.	Peclet.
Irish fossil marble	·00559	·0077	Coarse crystalline white marble.	Peclet.
Devonshire red marble...	·00525	·0058	Fine-grained calcareous stone.	Peclet.
Italian vein marble (white, grey veins).	·00512	·0047	Ditto ditto	Peclet.
Irish green marble	·00507			
Nummulitic limestone (a piece of Great Pyramid casing-stone, presented by Prof. C. P. Smyth).	·00433			
Caen (building) limestone	·00395	·0037 ·0035	Coarse-grained Lias building-stone	Peclet.
Chalk	·00384			
Black shale (Newcastle-on-Tyne).	·00178			
Cannel-coal	·00161			
Plaster of Paris (for castings)	·00163	·00145	Ordinary fine plaster (made up).	Peclet.
		·00122	Finest plaster for casting (made up).	Peclet.

Geological Aspects of the Results of the Experiments. *By* G. A. LEBOUR.

So far as these experiments have gone, they have certainly warranted the importance, from a geological point of view, which it was hoped they would have. Not only have the relative conductive powers for heat of a considerable number of rocks been arrived at, but a distinct grouping of the various kinds, according to their conductivity, has sketched itself out sufficiently clearly, if one considers the limited amount of substances yet tested.

Speaking broadly, one may say that the lighter and more porous the rock the greater its resistance to heat; the more compact and crystalline the less is this resistance. Of the specimens operated on, granite of averaged-sized grain offered the least resistance to the passage of heat, and coal and plaster of Paris were at the other end of the scale with the greatest resistance. The intermediate grouping of the other substances is interesting, and may be perhaps best understood by means of a mental diagram. Imagining a line divided into nine equal parts, the ten points being marked A, B, C, D, E, F, G, H, I, K respectively; then, according to the resistances calculated from the Table of conductivities given in the first part of the Report:—

A = Granite (with least resistance).
B = Grit.
C = Chalk.
D = Basalt.
$\left.\begin{array}{l}E = ?\\F = ?\\G = ?\\H = ?\end{array}\right\}$ (not known yet).
I = Shale.
K = Coal and plaster of Paris (highest resistance).

Now between A and B we get five kinds of marble and Calton trap-rock, and close to B, Kenton sandstone and Red Serpentine; between B and C we get Nummulitic limestone, alabaster, and slate.

When a much larger number of rocks have been experimented on we may hope to fill up the gaps, and show the natural grouping still more strikingly; and it will then become a question whether a scale somewhat of the nature of that just sketched out may not be constructed fully and accurately, which to the geologist would afford a ready means of referring new observations to their proper relative positions. A scale of this kind would become to the physical geologist something analogous to what the scale of hardness is to the mineralogist. Using even the imperfect one which is all we can arrive at yet, I have *translated*, so to speak, some of the detailed sections of strata in which underground temperatures have been observed into heat-resistance-equivalents with such results as I hope to be able to embody in next year's Report, showing how far the connexion which undoubtedly exists between the conductivity of the various rocks and the temperatures observed is disturbed, altered, and, I believe, occasionally reversed by external conditions. I have especially worked this out in the case of the South Hetton Colliery section, which for the accuracy of the temperature observations and the exactness of the boring records, together with considerable depth, is second to none (see Brit. Assoc. Report, 1872, p. 132). In this case an evident relation is observable between the calculated conductivities and the thermometric results. This case and the others, however, require considerably more working out before the result can be published.

Second Report of the Committee, consisting of Sir John Lubbock, *Bart.,* Prof. Hughes, Prof. W. Boyd Dawkins, Messrs. L. C. Miall *and* R. H. Tiddeman, *appointed for the purpose of assisting in the Exploration of the Settle Caves (Victoria Cave). Drawn up by* R. H. Tiddeman, *Secretary.*

The Committee have to record their deep sorrow at the loss sustained by the death of one of their number, the late Professor Phillips, a loss so universally felt, that any remarks upon the matter would be superfluous; suffice it to say that Professor Phillips took great interest in the exploration, and was very anxious for its further prosecution.

On the 18th of September the Committee with a select party of the Members went to see the Cave and the Cave Collection at the invitation of Mr. John Birkbeck, Sen., and were most hospitably entertained by him and his son, the Treasurer and Secretary to the Settle Committee. Although the weather was very bad and dusk came on earlier than was convenient, enough was seen to show the members of the expedition the chief bearings and difficulties of the exploration. On their return, the Museum at Giggleswick School was visited, and much satisfaction was expressed at the results already obtained, Professor Phillips in particular being very warm in his admiration.

At a Meeting of the Settle Committee held at Giggleswick on the 9th of October, Sir J. P. Kay-Shuttleworth, Bart., in the chair, the further working of the Cave was discussed, and it was decided that work should be recommenced so soon as subscriptions to the amount of £100, inclusive of the Association grant, had been received. It was further proposed and agreed that your Reporter should be entrusted with the scientific direction of the work. There being a debt of over £37 from the work of the preceding year, Mr. John Birkbeck, Sen., one of the most energetic promoters of the work from the commencement, generously paid that sum in order that the Committee might start afresh unhampered by any liabilities.

The Settle Committee have raised and expended in the course of the year, besides the British-Association grant of £50, £113 4*s.* 3*d.*

On the 7th of October a most important communication was received from Professor Busk. It was to the effect that a certain bone from the cave, which had been in his keeping some time and had been doubtfully referred to elephant, was undoubtedly human—a fibula of unusually clumsy build, and in that respect not unlike the same bone in the Mentone skeleton. This bone was exhumed by the Committee in May 1872, and was lying in juxtaposition with and under circumstances which left no doubt of its having been contemporary with *Ursus spelæus* and *ferox*, *Hyæna*, *Rhinoceros tichorhinus*, Bison, and *Cervus elaphus*; also close by it were two small molars of *Elephas.* It was at first supposed that these were *primigenius.* Dr. Leith Adams, however, during the past year expressed a doubt upon the determination, and after a careful comparison with type specimens in the British Museum, pronounced them to be *Elephas antiquus*, an opinion in which Mr. T. Davies concurs. Professor Busk, after examining them again does not commit himself to a definite opinion, but thinks on the whole that they are most likely *antiquus.* The balance of opinion, therefore, strongly preponderates in favour of Dr. Leith Adams's decision, and this is important as extending the range of that species. It had been before found at Kirkdale, but was previously unknown in the north-west of England.

On the 9th of December Professor Busk read a paper upon the human

fibula to the Anthropological Institute. He states that "there is nothing in the condition of the bone opposed to its belonging to the most remote antiquity, nor to its owner having been coeval with the extinct mammalia (before mentioned), with whose remains the specimen, as to condition, differs in no appreciable respect. Its interest, therefore, as representing one of the earliest extant specimens of humanity, will be at once obvious. But in another regard also it appears desirable that some notice of it should be placed on record. The very unusual form and thickness of the bone have caused such great difficulty in its recognition as human, that it is well worth while to draw attention to its peculiarities." Professor Busk proceeds to state that after much hesitation he was induced to think, at the suggestion of Mr. James Flower, that the bone in question might be referred to a small form of elephant; but considerable doubt remained on their minds until Professor Busk saw the Mentone skeleton at Paris, and noticing the thick and clumsy fibula belonging to it, was at once struck with the apparent resemblance between it and the Victoria-Cave bone. Following up this suggestion, Mr. James Flower discovered in the Museum of the College of Surgeons a recent human fibula of unusual thickness, which at once removed all doubt. The circumference of the cave bone about the middle is 2″·2. The unusually thick fibula with which Professor Busk compares it measures 2″, whereas he considers that ordinary full-sized human fibulas may be taken at from 1″·4 to 1″·8. It is obvious, therefore, that the Settle specimen is unusually thick. Professor Busk expresses his opinion that it does not appear from the form of the bone that the corresponding tibia was platycnemic, but he hopes that further exploration may clear up this and other interesting points. (Journal of the Anthropological Institute, vol. iii. No. 3, pp. 392–4.)

This communication was of the greatest interest, for it had been some time before pointed out that there was much chance of the beds in which this bone occurred being preglacial, or at any rate of an age preceding that time when Scotland, a great part of Ireland, and the north of England were slumbering beneath a great sheet of ice similar to those which now cover the greater part of Greenland and enshroud a portion of the southern hemisphere.

The Committee was decided by this in its course of work for the year. The question was one of such importance, that we felt the first thing to be done was to develop all the evidence that could be procured upon the question of whether these beds containing the older mammals and Man were of preglacial or interglacial age or not.

In order that these operations may be the better understood, it is necessary briefly to recapitulate the order and succession of beds inside and outside the cave. The three principal beds inside the cave are

The Upper Cave-earth,
The Laminated Clay,
The Lower Cave-earth.

These beds were described by your Reporter in a communication to the Settle-Caves Committee early in 1871, and subsequently to the British Association in 1872, but appeared in full in the 'Geological Magazine' for January 1873, to which he must refer for detailed description. In those communications reasons were given for thinking it probable that the laminated clay was accumulated under glacial conditions from the muddy water of a glacier or an ice-sheet. Such water would penetrate hollows in the rocks anywhere, and have a tendency to throw down its mud. Subsequent explorations have only served to confirm this view. First (in 1872) came the discovery of the Pleis-

tocene fauna at some depth below the laminated clay, they never having been found above it. Next, the exploration brought to light the existence of a bed of glacial boulders resting on the denuded edges of the lower cave-earth. The work of the past year has shown exceedingly well the extent and importance of this bed, and further has brought to light the existence of several well-glaciated small boulders in the laminated clay itself. This clay, so far, has yielded no organic remains. It ranges quite across the cave, and is coextensive with the explorations so far as they have gone, and in one place attains a thickness of 12 feet. It has been a horizon of great importance from its continuity, distinguishing the earlier from the later beds. The latest work in chamber D (on the right), however, appears to show that it is diminishing in thickness as we go inwards in that direction. Besides the main bed of it, many of the little chinks between fragments of rock in the lower cave-earth have been filled up with it. This filling in may have occurred at about the same time as the formation of the great mass above; for certainly glacial conditions imply amongst other things the running of much muddy water, and wherever preexisting chinks occurred, they would have much chance of being filled up. Laminated clay of course may be, and often is, formed under other than glacial conditions (that of the Victoria Cave, indeed, bears a strong resemblance to the famous Nile-mud); but here its thickness and the contrast it affords to the deposits above and below, taken with its extent, seem to demonstrate a change and a long continuance of distinct physical conditions.

It was noticed by those who visited the Victoria Cave last year that it is approached by a narrow cutting on the right as you face it. This had been made through a great thickness of "screes" or limestone talus; and below that talus, close to a large fallen block of limestone, which, with the face of rock on the right, formed a natural arch about 7 feet high, were visible at that time a few glaciated boulders. It was determined to expose these boulders and follow them, noting their position and range; but, in order to do this, we were under the necessity of removing a great mass of talus. Moreover, the "tip" of the old workings had accumulated in the front to such an extent as to seriously impede the operations. We therefore proceeded to remove a large breadth both of the tip and of the talus. The removal of the tip was of course mere mechanical labour, but the talus was removed with careful searching for the following reasons.

In the first place, it occurred to us that if the boulders beneath the cliff had fallen from that cliff, or from hollows in it, it was not improbable that other boulders might be found at different heights in the talus.

Secondly, we thought that if the boulders at the bottom of the talus had been deposited in their position in glacial times, and the talus represented the wearing away of the cliff by frost and other atmospheric influences, we might get a succession (an imperfect one, but still a succession) of the different forms of life which had followed one another through that long period.

Our first inquiry established the fact that through this great thickness (19 feet) of talus, from the base of the Roman layer which lies within the first two feet of the surface down to the horizon where the boulders lie in a great mass, not a single fragment of foreign rock, whether of Silurian grit, of Millstone-grit, or of limestone, other than that of which the cliff above is composed, occurred. The whole mass consisted of sharply angular fragments of white limestone. No rounded forms existed; nothing with any of the characteristics of ice-worn boulders or of stream-borne pebbles. The whole deposit spoke of the slow wearing away of a cliff, free from drift, by the

ordinary effects of winter frosts and summer rain. The edge of the cliff, on the retiring of the ice-sheet, was probably as free from glacial drift as we now find it.

Our second inquiry, which proceeded simultaneously with the first, met with only negative results. From the bottom of the Roman layer to the main mass of the boulders we met with no bones whatever, nor with any evidence of man's presence*. If, through the long time represented by these 19 feet of talus, animals existed in the neighbourhood, either they did not happen to die at or to be carried to the spot excavated, or their bones have been entirely dissolved by the action of rain. The former seems the more probable alternative; for if bones were dissolved, some remains of teeth at any rate would probably survive. A few bones, however, were found upon and among the boulders; these we have not yet had an opportunity to determine, and from their position it is doubtful to what age they may belong, for it is quite possible that they may have been washed out of the sloping denuded edges of the lower cave-earth on which the boulders rest. One appears to be a fragment of a very large bone, and possibly may be elephant; another is the os calcis of an ox.

The Roman layer, as the black band is with much reason called, contained several different kinds of pottery, some coarse and black, others white, and some red Samian ware. Of bronze articles six were found: two were bracelets, one consisting of three strands of wire twisted, with the hook by which it was fastened still remaining at one end; a second was thicker, consisting of five strands, but merely a fragment, only one fourth of what must have been its entire length; a band of thin bronze plate, which looks as if it might have bound a sword- or dagger-sheath; the bow end of a broken key; a scent-box or vinaigrette perforated with four holes, in appearance something like the top of a peppercaster, only one side of it remaining, together with the hinge still in working order, and the loop by which it was suspended round the fair neck of its wearer. Similar ornaments are figured in 'Roman Antiquities, Mansion House,' by Mr. J. E. Price, F.S.A., to whom we are indebted for its identification. A sixth object was found amongst some of the Roman layer which had been thrown over the tip, and is of doubtful age. It is a circular plate $1\frac{1}{2}$ inch in diameter, with a hole in the centre and two rivets at the back. It must have been affixed to some perishable material, for the rivets which project for some distance at their distal ends are quite perfect. It seems to have some traces of silvering at its centre. During the removal of the talus, the Reporter found three rudely discoidal pieces of Carboniferous gritstone, which appeared to have been roughly chipped to a diameter of between 5 and 6 inches. They were red, and had evidently been subjected to fire; most probably they had been used as pot-boilers, and their discoidal form was given to them that they might better fit the bottom of the pot. They were from the upper portion of the talus, that containing the pottery, but the exact position had been forgotten by the workmen.

As the summer advanced, the talus and overlying "tip" were so far removed that it was determined to convene a Meeting of the Committee and others to witness the removal of the last layers of talus and the uncovering of the boulder-bed. Invitations for the 6th of July were issued to all the Committee, to all who had written papers on the cave, and some other geologists.

Of the British Association Committee, only Mr. Miall and I were able to

* The Neolithic layer appears to have died out down the slope, or to have coalesced with the Roman layer.

attend; Mr. John Birkbeck, Jun., represented the Settle Committee: we had the valuable assistance of Messrs. Aveline, Dakyns, and other gentlemen. We were unfortunately deprived at the last moment of the valuable services of Professor Ramsay, who had expressed his intention of being present, but was prevented by public business.

In the course of the 6th and 7th of July the boulders were quickly brought to view and in great numbers; we counted over two hundred, of dimensions from a few inches to 6 feet in diameter, besides numberless smaller ones which it was not possible to preserve. Wherever a boulder was exposed it was left *in situ*, and the clearing away of the talus proceeded along the face of the bed. In several places we found a little clay above the boulders; but it was apparently of very recent introduction, and had been washed into the talus by the draining of water from above before the workings had got down to their present level. This was apparent from its containing blades of grass and pieces of straw which had not rotted away.

The boulders were found to be lying in an irregular layer from 3 to 4 feet thick at bottom, dipping outwards from the cave in a direction W. 40° S., and extending across its mouth at the level where we were then working; but at the north-western extremity of its range it curved round more to the north, and therefore dipped more westerly, showing in all a breadth of glacial deposits of about 12 yards. The boulders consisted almost exclusively of blocks of Silurian grit and of Carboniferous Limestone in about equal numbers, but there were one or two of Carboniferous Sandstone. The form was quite enough to distinguish the Carboniferous Limestone boulders from the sharply angular blocks of the talus; but, besides, many of them were of black bituminous limestone, and not of the white limestone in which the cavern is excavated. They were nearly all of well-marked glacial form, and most retained glacial markings. One round pebble of limestone was found near the base of the bed. The sites, dimensions, and arrangement of some of the principal were noted with reference to a level datum-line running N. 40° W. from a mark upon the wall of rock on the right, and after the section had been well cleared of talus; the boulders were marked (S) for Silurian and (L) for limestone, and then photographed. Angular pieces of limestone, similar to those in the lower cave-earth and in the talus, were mixed up with boulders throughout, and the whole was filled in with mud, but much of it appeared to be rather recent. The boulder-bed thinned away upwards, and is apparently thickening rapidly towards the dip; doubtless it will be found much thicker at a lower level.

In accordance with a suggestion from Professor Prestwich, a hole was dug in front of the large fallen block which forms the arch already mentioned, and the boulder-bed penetrated. A great many large and small boulders were dug out of this hole. Beneath was a bed of angular gravel filled in with clay a few inches thick. When washed, the small pieces of stone of which it was composed were found to be really small boulders, many of them scratched and bruised. Whilst wet it bore some resemblance to the gravel which covers little cones of ice low down upon a glacier near the moraine, and which offers such apparently good, but really bad foothold to unwary travellers*. Below this were a few inches of yellow clay, which Mr. Jackson, our Superintendent, says is similar to that which was found at the bottom of the 12 feet of laminated clay in the 25-foot shaft in Chamber B. This is an interesting point; for if the laminated clay and the boulder-bed are both of glacial age, it seems likely that this thin bed of yellow clay

* Forbes, 'Theory of Glaciers,' p. 241.

beneath them may have been forming simultaneously inside and outside the cave; and these two spots, we believe, are the only places where we have found distinctly yellow clay during the explorations. Some small fragments of bone were found beneath the yellow clay in ordinary cave-mud with angular limestone, to all appearance lower cave-earth, similar to that more fully exposed in the cave; but we came down upon some very large blocks of limestone, and did not think it advisable to enlarge the hole.

This is the only vertical hole which the Committee have dug this year, and it is shallow, not more than 4 feet deep. All our operations have been conducted by digging out in horizontal layers, to avoid any confusion which might arise from the falling in or mixing up of things of different ages in vertical shafts.

Those who were present at the uncovering of the boulders were unanimously of opinion that they had not fallen from the cliff in postglacial times, for the following reasons:—

1. The cliff immediately above the cave is free from any boulder deposits for a considerable distance.
2. The boulders lie at the base of all the talus, which must have been forming ever since glacial conditions declined, and no other falls of even isolated boulders have occurred throughout the whole thickness of screes.
3. The boulders are so close beneath the cliff, that if all the limestone which has fallen from it and is now lying on the boulders could be restored to the cliff, it would project so much further forward, that the fall of the boulders from the cliff to their present position would be impossible.

Professor Prestwich and Mr. Bristow, who were good enough to visit the cave earlier in the year, both give it as their opinion that the boulders had not fallen from the cliff, but were part of the ordinary drift deposit which covers the bottom of the valley and lines the hill-sides up to the bottom of the cliffs hard by.

The important bearing of these questions upon the correlation and age of the drifts of England and the antiquity of Man cannot be overestimated*. If rightly interpreted, it may give the key to much that has hitherto been unsatisfactory, and even contradictory, in Pleistocene geology.

In conclusion, the Committee have much pleasure in offering their thanks to the Settle Committee for the generous and liberal manner in which they have carried on this important investigation, and to Mr. John Birkbeck, Jun., for his valuable services as Honorary Treasurer and Secretary from the commencement.

They have also to thank the following gentlemen for assistance kindly given:—Professor Busk, Dr. Leith Adams, Mr. Franks, and Mr. T. Davies of the British Museum.

Your Committee propose that they may be reappointed.

* "The Relation of Man to the Ice-sheet in the North of England," 'Nature,' vol. ix. No. 210, p. 14.

On the Industrial Uses of the Upper Bann River.
By JOHN SMYTH, Jun., *M.A., C.E., F.C.S.*

[A communication ordered by the General Committee to be printed *in extenso.*]

THE river Bann rises in the Mourne Mountains and flows a distance of 85 miles, in a northerly direction, through Lough Neagh into the North-Atlantic Ocean at Coleraine. Its drainage-area, including that of its many tributaries and the surface of Lough Neagh, is 2345 square miles, and is surpassed in Ireland only by that of the Shannon, which is 6946 square miles, and the Barrow Nore and Suir, which is 3410 square miles. This area or rainfall gathering-ground is well surrounded by mountains flanked by high tableland, the descent from which is rapid. The banks of the various branches of the Bann, therefore, offer peculiarly favourable sites for mills, a fact which has been well taken advantage of by the industrious inhabitants of this prosperous district, and, to a large extent, contributed to the establishment of the linen trade in the north of Ireland. The principal branches or tributaries of the Bann are the

Blackwater river,	which drains	part of the	counties of	Armagh, Monaghan, and Tyrone.
Ballinderry	"	"	"	Tyrone and Londonderry.
Moyola	"	"	county of	Londonderry.
Claudy	"	"	"	"
Agivey	"	"	"	"
Maine	"	"	"	Antrim.
Six-Mile Water	"	"	"	"
Upper Bann	"	"	"	Down.
Cusher	"	"	"	Armagh.

Although the Upper Bann drains a much smaller area than either the Blackwater or Maine, it is the most important and interesting in an economic and engineering aspect. For in that valuable work 'The Industrial Resources of Ireland,' published thirty years ago by Sir Robert Kane, he says "The Upper Bann is the most fully economized river in Ireland," and refers to it as of an example worthy of imitation in the application of engineering science to the development of natural resources by the construction of its reservoirs. I therefore proceed to describe what has already been done to turn its natural advantages to good account and the result.

The Upper Bann, from its source to the point where the water from the last mill is returned to the river, is about 31 miles long, and drains an area of 134 square miles, or one seventeenth of that of the Bann-system. From this point to Lough Neagh, a distance of 10 miles, it is navigable, and forms with the Cusher river and canal part of the Newry navigation. There is no record, as far as I have been able to discover, of the time mills were first erected on the Upper Bann. The weir-dams which are found in the old maps bear the appearance of ancient construction; and reference is made in ancient leases to the repair of weir-dams and the necessity of grinding corn at the manor mill. There is no doubt but that the establishment of the linen trade on the river Bann is of very ancient date. It is stated that in the year 1772 there were 26 bleach-mills on the Bann, and the linens from that district were well known and highly esteemed in England and Scotland. The machinery in these mills was driven by undershot-wheels, which only give out about 25 per cent. of the theoretical useful effect of the fall of water. About the year 1833, however, application was made by Mr. Law, of Hazelbank mill, to the late Sir William Fairbairn, F.R.S., the celebrated hydraulic engineer, who,

through a professional connexion with Ireland of fifty years, has so much advanced the usefulness of the Upper Bann by improved mechanical and engineering appliances; unfortunately for the world that eminent and invaluable life has just terminated, after having accomplished more than the most sanguine could hope to see realized in a lifetime. He put up an iron breast-wheel, which gave great satisfaction and is still capable of doing good work. It was at first used for driving linen beetling-machines, and was calculated to give a useful effect equal to 60 per cent. of the theoretical power of the water. He erected another of the same kind shortly after this at Seapatrick, to drive beetling-engines and power-looms, and subsequently several others were put up at different mills on the river by Mr. Boyd and the firm of Coates and Young, of Belfast. In 1835 the principal mill-owners formed themselves into a provisional Committee to take steps to procure a better and more regular supply of water by the construction of reservoirs. They placed the matter in the hands of Sir William Fairbairn, who, assisted by J. F. Bateman, Esq., F.R.S., surveyed the collecting-grounds of the river Bann and its several tributaries, and made an excellent and most interesting report of the water-bearing resources of the district. He recommended the construction of two impounding reservoirs, Lough Island Reavy and Deer's Meadow, and one auxiliary one, the Corbet Lough. The Bann Reservoir Company was then formed, and Lough Island Reavy first constructed according to the plans and under the superintendence of Mr. Bateman, and was finished in the latter part of the year 1839.

The Corbet reservoir was also constructed, but not to the full extent contemplated, the embankment having been made to impound the water to a depth only of 11 feet 3 inches instead of 18 feet. Much difficulty was encountered in the work, which was not finished till the year 1847.

The Deer's-Meadow reservoir was abandoned, as the works were of a heavy character, and the gathering-ground being small, it was feared there would not be sufficient water to fill it. A detailed account is given of the works at Lough Island Reavy by Mr. Bateman in the 'Transactions of the Institution of Civil Engineers' for 1841 or 1842, so it is not necessary to do more than to describe a few specialities. The works are most substantial, and the embankments never showed any deficiency or weakness; one peculiarity in their construction is the use of a wall of peat on the water side of the puddle-wall and another on the water face of the embankment. Its application has been most successful, as there has been no leakage through the embankment. I have found peat used in this way in conjunction with clay puddle most efficacious in mill-dams and river-courses, and for surrounding smooth iron pipes in their passage through banks; indeed the value of its use is well attested by the prevalent practice of its traditional adoption in difficult cases in those districts where it is procurable. Some experiments made to determine the rationale of its action, showed that, like a sponge, it expands to fill the space left by the shrinkage of the puddle; if this space were not thus occupied, water would trickle into the fissures and gradually wash soft material away.

In the solid ground under the main embankment a culvert is built about 150 feet long, filled at the half of its length by a solid plug of masonry, into which three iron pipes are inserted. These pipes are each 18 inches in diameter; one of these, which lies above the other two, is for use in cases of emergency, only 7½ feet long and closed (by a dead flanche) on the discharge end; the others, which are laid on the bottom of the culvert, are 82 feet long and provided with sluice-valves. These valves are surrounded by an arched chamber (an enlargement of the outer culvert), and are regulated, according

to the depth of water in the reservoir, to give the regular supply allowed to the mills. The greatest depth to which the reservoir is filled over the level of discharge of these pipes is $38\frac{1}{2}$ feet; when this is the case the surface of the lake is about 250 acres in extent. It was intended to have been 40 feet, but the works were not carried out to that extent. The culvert, as Mr. Bateman tells us in his paper, has given some trouble, since the superintendent did not carry out the work in accordance with his designs, having surrounded the arch with rubble-backing. The cement, which was made on the ground from the specification of M. Vicat, just then published, gave way under the water pressure, was washed out of the joints and allowed the water to escape from the reservoir through the rubble-backing. Mr. Bateman then had part of the backing removed and replaced by puddle, and the inner joints of the tunnel caulked with oakum. This cured the evil for some time; but in a few years the leakage again appeared, and had increased so much in 1867 that Mr. Bateman was brought over to examine it. He recommended as the only effectual remedy to the leakage to cut out the centre of the embankment down to the culvert, take away the rubble-backing and all loose material around the culvert, and erect perfectly water-tight walls closely connected with the existing masonry on each side of the puddle-trench. As it was then too late in the season to carry out this great work, he recommended as a temporary expedient to repeat the measures adopted in 1839, of puddling round the mouth of the inner culvert and caulking all its open joints, also, if necessary, to make good the concrete under the invert. The Directors of the Bann Reservoir Company were unwilling to incur the expense of cutting out the centre of the embankment, as it would not only have cost a large sum for the work, but also have stopped the rates for at least a year. I was therefore requested to make the smaller work, recommended as temporary, if possible so effectual in moderating or stopping the leakage as to prevent recourse being had to the larger work. I had therefore a portion of the bank excavated so as to expose about six feet of the culvert close to the forebay or mouth, the concrete under the invert removed for about three feet, and a close wall of fire-brick and Portland cement built under and around the culvert, with which it was closely united. The excavation was then made up with puddle and dry peat, so staunch as to prevent access of water from the embankment to the backing of the culvert, and the old plan of caulking and cementing the open joints prevented the water getting to it through the inside of the arch. This caulking was not carried out as completely as I wished, since it was then so late in the season that further delay in getting water into the reservoir would have been likely to entail serious loss; so only the points that showed weakness were attended to, and a lining of cement applied to the whole of the inner culvert.

The result was most satisfactory, as the leakage was almost entirely stopped, and since then has given no trouble. The insignificant escape then left, although somewhat increased by the softening of the cement in some of the joints, may be stopped when a convenient opportunity occurs by caulking; or the difficulty of the imperfect masonry may be got over by continuing the iron pipes back to the mouth of the culvert, and securing them there by a solid plug of masonry. A portion of this leakage is probably derived from a spring, as it is harder than the water in the reservoir. A more detailed description of these repairs may be found in a paper by me published in the 'Transactions of the Institution of Civil Engineers of Ireland,' vol. ix. p. 51.

Lough Island Reavy reservoir is 430 feet above the sea-level, and is mainly supplied from the Muddock river by a feeder of about one and a half mile

long, which leaves the river at a point 10 feet higher than the top level of the reservoir, and three miles from its source on the Butter Mountain. There are stop-sluices at the head or intake of the feeder to turn the water back into the river when the reservoir is full. Another feeder from the Moneyscalp river supplies to the reservoir about one fourth the quantity derived from the Muddock, and is also supplied with stop-sluices. This Moneyscalp river runs to the sea at Newcastle. The whole rainfall gathering-ground of Lough Island Reavy, including the lake itself, is about five square miles. The water from the pipes for the supply of the mills is delivered into an open conduit, which is about one mile long, and joins the Muddock again about a mile below the intake.

The river Muddock is one of the most important branches of the Bann; it rises about 1200 feet above the top water-level of the reservoir, and consequently falls nearly 400 feet per mile above the intake of the feeder. For three miles below the reservoir the fall is about 40 feet per mile, and from that to its confluence with the river Bann (which is also three miles) the fall is only 3 feet per mile. This last three miles of the river Muddock has been a source of great trouble and expense to the Bann Reservoir Company, as it is not only sluggish in its flow, but exceedingly tortuous, and consequently continually silting-up. There is a difficulty in point of law as to whether the riparian owners or the Reservoir Company should clean the river. This question is at present being argued. The Reservoir Company did clean out the river sixteen years ago, when they were in fault in not putting down the sluices at the intake of the Moneyscalp feeder when the reservoir was full; consequently in time of flood water flowed down the old Muddock river which had never done so before the formation of the reservoir; and the Company were held responsible under an arbitration and recommended to scour the river. As they had no power over the banks of the stream, they were obliged to pay large sums to the farmers for their use, and also for throwing out on and removing from them the scourings and weeds, although by the construction of the reservoir floods are caught which previously overflowed these low lands for the greater part of the year. Since then some of the banks have fallen in, and the weeds have increased so much as to form with the siltings a serious obstruction to the discharge of sufficient water for the mill supply, which in some places makes its way up the side drains, and (where the back drains are not attended to) overflows grounds lower than the banks; and actions have been taken against the Company. The banks also are low—indeed, for this three miles of the Muddock's course, under the level to which floods sometimes rise in the Bann at its mouth; consequently these floods make their way back and overflow to a great depth large tracts of low land on each side. The outlet is through a narrow bridge, and so, augmented by the Muddock's own floods, they are prevented from running off rapidly and thus injure these lands, for which the Bann Reservoir Company were obliged to pay damages.

There is a great obstruction to the flow of the Bann at its confluence with the Muddock, which if removed, and the channel of the Muddock altered for about fifty yards, so as to flow with instead of against the stream of the Bann, the Bann also widened and deepened for a short distance, and the narrow Muddock bridge referred to above widened and deepened, the floods of the Bann might in a great measure be prevented from interfering with the Muddock, and the drainage of the Muddock itself much improved. The Reservoir Company were at that time willing to unite with the proprietors of the land in carrying out this improvement, but the latter were not willing

to join. From the confluence of the Muddock to Kate's Bridge, a distance of six and a half miles, there is 27 feet 9 inches of unoccupied fall. There were two weir-dams on this reach, called Ronghan and Ballyroney; the former was taken down more than ten years ago, and the latter has become dilapidated since the mill was burnt a few years ago. From Kate's Bridge to Aughnacloy or Ervin's Weir, a distance of two miles, there is one fall of 7 feet 3 inches occupied by a corn-mill and $2\frac{1}{2}$ feet of unoccupied fall. The intake of the feeder to the Corbet reservoir from the Bann is about thirty yards above Ervin's Weir, and is regulated by sluices 20 feet wide, which admit a large quantity of water when the river is flooded. Outside these sluices a stone ridge or sill, at a level $1\frac{1}{2}$ inch below that of Ervin's Weir, is built across the widened mouth of the feeder to regulate between the Bann Reservoir Company and the mill-owners on this fall. On this sill the caretaker daily measures the depth of water, and, when he finds it below the standard, supplies the deficiency from the Corbet Reservoir; when that is exhausted he sends for a supply to Lough Island Reavy. The rainfall gathering-ground of the Bann above this point is eighty square miles, and there is a rain-gauge now kept there by the caretaker, who also keeps a register of the depth of the daily flow of water over Ervin's Weir and the daily height of water in the reservoir. The feeder is one and three eighths of a mile long and 24 feet wide. At its entrance to the reservoir there are self-acting gates, which close when the water in the reservoir is higher than that in the feeder. The area of the reservoir when full is 70 acres, and the greatest depth of water above the lowest point of discharge 11 feet 3 inches. The sill at Ervin's Weir is 7 feet above the lowest point of discharge, so the river raises the reservoir as much in excess of that height as the floods rise above the sill. A small stream at the north-east end of the reservoir makes it up to the top level in winter. The water from the reservoir is discharged through three iron sluices 3 feet wide each, and capable of being raised to a height of 1 foot: one only of these is now used. The sluice-frame is secured in a strong water-tight wall in the centre of the embankment, behind which is an arched chamber, into which the water flows, and passes down a conduit, a quarter of a mile long and 20 feet wide, to the river. There was only embankment required for this reservoir; a considerable portion of the feeder also required embanking. It cost more, in proportion to the extent of the works, than Lough Island Reavy, as the contractor was not able to carry out his contract, and the Company were obliged to finish it themselves. Lough Island Reavy cost for engineering works £15,000, and for land £6000. The capital of the Company is £31,000; deducting the reserve fund of £1000, there remains £9000 for the Corbet reservoir and parliamentary expenses. The income of the Company is derived from the falls, on which the charge is £10 per annum per foot to linen-bleachers, manufacturers, and spinners and flour-millers, and £5 to corn-millers and flax-scutch millers.

The fall from the outlet at Lough Island Reavy to the tail-race of the last mill at Moyallen is 350 feet; of this, 180 feet 2 inches are occupied by mills, and can be rated. Of this 180 feet 2 inches, 7 feet 3 inches are occupied by the Linen Hill mill, about one and a quarter mile above the intake to the Corbet reservoir, and 6 feet 4 inches by the Ardbrin Mill on Ervin's Weir at the intake. The remaining fall of 166 feet 7 inches is below the outlet from the Corbet reservoir, and is divided over a distance of eleven and a half miles of the course of the Bann, passing the towns of Banbridge and Gilford, and ending at Moyallen, below which the river is joined by the Newry canal and

the Cusher river. Of this 166 feet 7 inches, 155 feet 4 inches are rated at £10 per annum per foot fall, and 11 feet 3 inches at £5. Linen Hill and Ardbrin falls are also rated at £5, and make the total income £1675 8*s*. 4*d*.; but £224 11*s*. 8*d*. must be deducted from this for four falls unoccupied at present, leaving a net sum of £1450 16*s*. 8*d*. For so far the undertaking has not paid the shareholders well, as the expenses connected with the Muddock river sometimes absorbed the entire dividend; latterly, however, the dividend has amounted to above 3 per cent.; and if the present litigation was favourably settled and the falls more fully occupied, a fair return may be expected. The recent material advance in the price of fuel and the expected opening of the Banbridge Extension Railway should contribute to this end.

Lough Island Reavy reservoir has now been worked for thirty-four years, and has well borne out Sir William Fairbairn's anticipations of its utility in impounding water and giving out a supply to the mills. In his calculations, as no extended rainfall observations had been made in that district, he assumed the rainfall as 36 inches, which was the average for the whole of Ireland. He deducted one sixth of the rainfall for absorption and evaporation, and concluded there would be sufficient left to fill the reservoir once and a quarter, on the average, in the year. I have, however, maintained a rain-gauge at Lough Island Reavy since May 1861, and find the average fall at a level of 6 feet above the top water of the reservoir is 46 inches. That amount over the five square miles drainage-area of the lake yields 535,000,000 cubic feet, and the capacity of the reservoir filled to 38 feet 6 inches above the outlet is 270,000,000 cubic feet. A rainfall of 23 inches, if there were no loss, would fill the reservoir; but it requires about 30 inches to do so from the beginning of October till that of April (the season it is generally filled), and the evaporation during the other six summer months is about four times as much. We may therefore assume the loss to be about one third the whole rainfall, leaving sufficient to fill the reservoir one and one third times. The rainfall must be greater on the high ground than at the gauge, so that only one half the whole rainfall is probably available. The Butter Mountain, from which most of the drainage is derived, is peaty, which will account in some measure for the large amount of absorption on such steep ground. It is also to be remembered that the evaporation from the surface of the reservoir is very great. At the intake of the Corbet reservoir, where the drainage from eighty square miles of mixed flat and mountainous country passes down the river Bann, I found, on comparing the quantity passed over Ervin's Weir with the average rainfall for the year 1872, the former to be only one fifth the latter, equal to a loss of four fifths the rainfall by evaporation and absorption. This calculation can only be taken as an approximation, since Ervin's Weir is not constructed for accurate gauging, and I was obliged to deduct 20 per cent. from the calculated discharges as a rough estimate of the loss from the absence of a level ridge board and the broad and irregular surface of the weir; besides, to obtain an accurate idea of the amount of rainfall, returns should be obtained from a number of gauges well placed over the varying surface of the country. This inquiry as to the relative amount of rainfall and absorption in various districts of country is very interesting, and more information on the subject is desirable.

A register of the daily height of the water in Lough Island Reavy has been kept since 1847 by the caretaker. It shows that this reservoir has been of great service to the mill-owners on the Upper Bann, as during twenty-six years an average supplementary supply of about two fifths of the standard

summer discharge allowed over Ervin's Weir, or about 30 cubic feet per second (equal to two and a half horse-power to the foot fall at Sir William Fairbairn's estimate of 12 feet in its best application to a water-wheel equal to one horse-power), has been granted for 2663 days, or, on an average, 102 days yearly; and the reservoir has only been empty 303 days, or, on an average, eleven and a half days yearly. The Corbet reservoir has been of much more service than its capacity would lead one to expect, as it may be filled and emptied four or five times in each year by small floods in the river, and all the Sunday's water can be sent into it and let down to the mills on Monday and Tuesday. It is generally exhausted before the upper reservoir is called upon, and keeps up a supply when there is a scarcity in frosty weather in winter; and when a flood comes at the end of these short terms of scarcity it is ready to receive it, and thus diminish the amount of back water on the wheels. If its area were five or six times as great, it would be almost that much more valuable, as so many floods pass when it is full; for its drainage-area is about sixteen times that of Lough Island Reavy. According to the original plan, the embankment should have been raised so as to impound the water to a depth of 18 feet instead of 11 feet 3 inches, and contain 46,783,440 cubic feet instead of 28,177,221 cubic feet; unless, however, the intake from the river was at a much higher level, say at Linen Hill weir, it would not be much advantage, for the drainage-area of the lake itself is very small.

The register of the Corbet reservoir has not been kept so long or as accurately as that of Lough Island Reavy, so it is not possible to show so well the service it has done the mills; from the average of three years, however, and comparison with the register of Lough Island Reavy, I calculate it has given 120,000,000 cubic feet in the year, exactly one half that of Lough Island Reavy, or a good supply for fifty-one days; add this to the Lough Island Reavy supply, and there is a total of 153 days of twenty-four hours each. Sir William Fairbairn calculated that when all the reservoirs should be made (including the Deer's Meadow and the full completion of the other two reservoirs), there would be a supply of 60 feet per second for 108 days of twenty-four hours each year. Reducing it to 108 days, the supply really has been 44 cubic feet per second, which is very nearly in the same proportion to the amount that can be impounded as his calculation was to that proposed to be impounded. As the supply from the reservoirs has only failed, on an average, eleven and a half days yearly, the standard water-power may be said to have been almost constantly maintained. This constancy in the supply makes the Upper Bann most valuable as a power; indeed it is almost as good as steam-power, but at a much less cost.

Whilst the average value of water-power in Ireland is about £2 per horse-power per annum, on the Bann it may be estimated at £4 where only ten hours' work per diem is available, and £7 where constant work is maintained after paying the water tax. Steam-power on the Bann costs about £6 per annum per horse-power, calculating 4 pounds of coal equal to one horse-power per hour. The first cost and maintenance of works necessary to render these powers available would be greater in the case of steam than water. More convenient mill sites can, however, be obtained for the application of steam than water. On the Bann it is found more economical to work steam and water in conjunction where much power is required, as advantage can be taken of moderate floods to ease the steam; this method of working is particularly applicable to bleach-works, where the steam, after passing through the cylinder of a high-pressure engine, can be used for boiling and heating.

Table of Falls on the Upper Bann River from the

Number of miles further down course of river.	Name of Mill or nearest Townland.	Names of Occupiers.	Description of Mill.	Amount of Fall. ft.	in.
		Unappropriated	....	5	6
2	Roughan..	Alexander Stewart	Taken down	8	3
		Unappropriated	....	0	7
2	Ballyroney	Mrs. Murphy	Corn and Flax Scutch.	8	10
		Unappropriated	....	4	7
2½	Linen Hill	Alexander Porter	Corn and Scutch	7	3
		Unappropriated	....	2	6
1½	Ardbrin ...	William Kirk	Scutch }	6	4
	Aughnacloy.	Mrs. Ervin	Taken down }		
		Unappropriated	....	0	6
2¾	Corbet	John Simms	Linen Beetling }	9	6
	"	" "	Corn }		
¾	Balliervy ...	George Crawford	Linen Beetling	6	1
½	Lisnaree ...	Thomas E. Henry	Scutch	7	1½
¾	Ballydown	G. Lindsay and J. Lindsay	Linen Bleach }	7	2½
	"	" " "	" Beetling }		
¼	Tullyear ...	James M'William	Yarn Bleach	3	11
½	Banbridge.	" "	Linen Bleach	...	...
	"	" "	" Beetling }	9	11
	"	" "	Corn }		
1	Millmount	" "	Linen Bleach }	10	0
	"	" "	" " }		
½	Seapatrick.	William Hayes	Flax Spinning	8	6
	"	" "	" "	...	...
¾	Milltown..	W. Smyth and John Smyth, jun.	Linen Bleach }	8	2½
	"	" " "	" " }		
⅛	Lenaderg..	" " "	Linen Beetling }	5	4
	"	" " "	" " }		
¼	Banville ...	" " "	" " }	5	8
	"	" " "	" " }		
¼	Hazelbank.	Mrs. M'Tier and Miss Law	Flax Spinning }	8	7½
	"	" " "	" " }		
¼	Knocknagor.	William Uprichard	Scutch }	4	1
	"	" "	Corn }		
½	SpringVale	W. Uprichard and H. Uprichard	Linen Bleach }	13	1
	"	" " "	" " }		
¼	Millpark...	" " "	" "	7	1
⅜	Banford ...	T. Haughton and J. Jaffé	" " }	7	10
	"	" " "	" " }		
¼	Mount Pleasant.	George Mullin	Linen Beetling }	6	2
	"	" "	Flour }		
⅛	Glen Mills	" "	"	8	6
⅜	Thornhill.	H. D. M'Master and J. G. M'Master	Linen Beetling	3	9
1	Gilford ...	" " "	Corn }	19	6
¼	"	" " "	Flax Spinning }		
	"	" " "	" "	...	...
1¾	Moyallen.	David Mercier	Flour	6	5
21½				10	10

Confluence of the Muddock River to Moyallen Mill.

Prime Movers.			Remarks.
Water-wheels.	Steam-engines.	Estimated aggregate Horse-power.	
....	....	......	Weir and race levelled.
....	....	......	Weir broken down.
2 Undershot ...	....	18	Mill partly burnt; not working.
1 Breast	....	15	N. side. [feeder. Water divided
....	....	..	S. „ Intake of Corbet on same fall.
1 Iron Breast...	....	44	S. Water divided.
1 Undershot ...	....		N.
1 Thomson's Vortex.	....	25	
2 Undershot ...	....	18	
1 Iron Breast...	1 High-pressure ..	90	Wheel and Engine connected. Water
1 „ „	....		.... divided.
1 Undershot ...	1 High-pressure ..	26	Wheel and Engine connected.
....	2 Condensing......	170	Near Beetling-mill.
1 Turbine	1 „		N. side. Water divided.
1 Undershot ...	....		S. „
1 Iron Breast...	1 High-pressure ..	106	Wheel and Engine connected. Water
1 „ „ ...	....		.... divided.
1 „ „ ...	1 Condensing......	300	Wheel and Engine connected.
....	1 „		Close to foregoing.
1 Iron Breast...	1 Condensing......	130	Wheel and Engine connected. Water divided.
1 „ „ ...	1 High-pressure ..		
1 Undershot ... [dershot. 1 Poncelet Un-	....	20	Water divided.
1 Iron Poncelet Undershot. 1 Undershot ...	....	20	Water divided.
1 Iron Breast ..	....	200	.... Water
1 „ „ ...	1 Condensing......		Wheel and Engine connected. divided.
1 Undershot ... 1 „ ...	....	12	Water divided.
1 Iron Breast...	....	120	.... Water
1 „ „ ...	1 Condensing......		Wheel and Engine connected. divided.
....	....		Not working.
1 Turbine	2 High-pressure ..	176	Wheel and Engine connected. Water divided.
1 Small Breast .	1 Condensing......		
1 Undershot ...	....	65	.... Water divided.
1 Breast	1 Condensing......		Wheel and Engine connected.
2 Iron Breast...	....	59	Wheels close together.
1 Undershot ...	....	12	
1 Breast	....	760	Water divided. Wheel and Engine connected.
1 Iron Breast...	2 Condensing......		
....	2 „		Close to foregoing.
1 Iron Breast...	1 „	110	Wheel and Engine connected.
		2496	

For the utilization of the water-power of the Bann there are thirty-one mill-falls (besides the two mentioned before, where the weirs have been taken down): eight of these are above the confluence of the Muddock, one of them on the Rocky river and one on the Leitrim river (both important branches of the Bann); the other six are on the Bann itself. As none of these derive any advantage from the reservoirs, the Deer's Meadow not having been made, their power is small and variable, and they are nearly all occupied by small corn- and scutch-mills. In the preceding Table (pp. 146 & 147) full particulars are given of the remaining twenty-five falls, which are more important, inasmuch as, in addition to the Bann, they command the water of the Muddock and the reservoirs.

An inspection of the Table shows that the first four falls are at present unprofitable to the Reservoir Company, as the rates annually struck on them are annually remitted on account of the mills not being worked. There are several reasons for this: some of these are flax-scutching mills and have been burnt; and as that is a bad business at present, and steam scutch-mills can be kept going by using the waste products of the scutching for fuel, there is no inducement to put up new mills and pay the reservoir rate. Although the rate is the same as below the Corbet reservoir, these falls are deprived of the advantages of that reservoir; and the busiest season for both scutch- and corn-mills is subsequent to the time the greatest use is made of Lough Island Reavy. They are at a distance from large and important towns, surrounded by a poor part of the country, much of which is mountainous.

The Banbridge Extension Railway is almost finished as far as Ballyroney Mill, and runs close to the river all the way from Banbridge; when it is opened a great stimulus will be given to the trade of that part of the country, and, it is expected, capital drawn to it for the establishment of mills engaged in permanent manufactures, such as have clustered themselves around Banbridge. An improvement may therefore be looked for; and manufacturers, as they become alive to the fact that steam, although a very convenient, is a most expensive power, will gladly avail themselves of such a cheap and constant water-power as the Upper Bann offers.

A consideration of what has been already done on the Upper Bann shows that had the Act of Parliament been such as, after forty years' experience, is now adopted for such works, and power over the various watercourses secured, much litigation would have been prevented, and the Bann Reservoir Company much more prosperous; also, that many of the falls could be nearly doubled in value by improved water-wheels.

I hope this brief description of what has been already done on the Upper Bann may induce other districts, profiting by this experience, to economize the vast amount of water-power that runs to waste in all parts of Ireland. Were such the case, it would go far to make up for the want of coal in that country, and much promote its industrial prosperity.

The Upper Bann was formerly celebrated for its trout-fishing, which has been much injured of late years by the discharge of flax steep-water into the river, instead of lifting the flax out of the water when the water is low. It is said if some improvements were made in the weirs, salmon would come up the river. Eels can be taken during floods, but are not much sought after. Pearls have been found in rare instances in the river. The water is exceedingly soft (about 5°, Clark's test), and peculiarly well adapted for bleaching, which is extensively carried on at the various establishments along the river.

Report of the Committee, consisting of Professor HUXLEY, *LL.D., F.R.S.,* Professor HARKNESS, *F.R.S.,* HENRY WOODWARD, *F.R.S.,* JAMES THOMSON, JOHN BRIGG, *and* L. C. MIALL, *on the Structure and Classification of the Labyrinthodonts. Drawn up by* L. C. MIALL, *Secretary to the Committee.*

(PLATES IV.–VII.)

IN this, as in the preceding Report, the Committee have included the Permian and Secondary Labyrinthodonts. Before their work had made much progress it was perceived that the Carboniferous species cannot be satisfactorily studied alone.

The present Report treats of all the well-investigated species hitherto recorded, and the Committee have not, therefore, recommended their own reappointment. In laying down their commission, they desire to thank the many friends who have assisted their labours. Professor Cope, Messrs. Embleton and Atthey, Mr. T. P. Barkas, and the Natural-History Society of Northumberland and Durham have forwarded publications on Labyrinthodonts; the authorities of the Warwick and Bristol Museums, Mr. John Ward of Longton, Mr. James Thomson of Glasgow, Mr. George Maw of Broseley, Mr. T. P. Barkas of Newcastle, and Mr. William Horne of Leyburn, Wensleydale, have sent specimens for examination; while Professor Cope and Mr. Thomson have sent photographs from fossils in their possession. Every facility for examination of Labyrinthodont remains has been afforded by the officers of the various public museums visited; and two members of the Committee have had the advantage of inspecting a large part of the valuable collection belonging to Mr. Thomas Atthey, of Gosforth, near Newcastle.

It does not appear necessary to prefix to the arrangement of the Labyrinthodonts here proposed any discussion of the opinions of previous writers on this subject. In no classification that has yet appeared have even one fourth of the genera here recorded been noticed at all. We are sensible of the great imperfection of the materials at our command, and can only regard the present arrangement as a sketch to be filled in and corrected hereafter.

CHARACTERS OF THE ORDER.

Body elongate, furnished with a tail. Postorbital, supratemporal, epiotic, and paired supraoccipital ossifications usually present in the skull. A parietal foramen. Palatine and vomerine teeth in most or all. Dentine usually much folded[1]; the apex of the young tooth two-edged. A sclerotic orbital ring in some, possibly in all. Vertebræ amphicœlous. Three thoracic plates[2], and a ventral armour of small scutes. Limbs four[3], often, perhaps usually, pentadactyle.

TABULAR VIEW OF THE CLASSIFICATION OF THE LABYRINTHODONTA.

A. *Centra of dorsal vertebræ discoidal*[4].—Genera 1 to 23.

I. EUGLYPTA. Cranial bones strongly sculptured. Lyra conspicuous. Mandible

[1] Slightly folded at the base only in some of the teeth of *Dendrerpeton*; simple in *Hylonomus* and *Hylerpeton.*

[2] Unknown in the *Microsauria*, as well as in various genera and species which have been hitherto represented only by fragmentary examples.

[3] Believed to be wanting in *Ophiderpeton* and *Dolichosoma.*

[4] This character is not of primary importance, but seems to be available for an arrangement determined by other considerations.

with well-developed postarticular process. Teeth conical; their internal structure complex; dentine much folded. Palato-vomerine tusks in series with small teeth. Short inner series of mandibular teeth. Sculptured thoracic plates, with reflected process upon the external border.

* *Palatine foramina large, approximated.*

† *Mandible with an internal articular buttress.*

‡ *Orbits central or posterior.*

1. Mastodonsaurus, *Jäger.*
2. Capitosaurus, *Münst.*
3. Pachygonia, *Huxley* (?).
4. Trematosaurus, *Braun.*
5. Gonioglyptus, *Huxley.*

‡‡ *Orbits anterior.*

6. Metopias, *Von Meyer.*
7. Labyrinthodon, *Owen*[1].

†† *Mandible without internal articular buttress.*

8. Diadetognathus, *Miall.*

** *Palatine foramina small, distant.*

9. Dasyceps, *Huxley.*
10. Anthracosaurus, *Huxley.*

II. Brachyopina. Skull parabolic. Orbits oval, central or anterior. Postarticular process of mandible wanting (?).

11. Brachyops, *Owen.*
12. Micropholis, *Huxley.*
13. Rhinosaurus, *Waldheim.*
14. Bothriceps, *Huxley.*

III. Chauliodonta[2]. Skull vaulted, triangular, with large postero-lateral expansions. Lyra consisting of two nearly straight longitudinal grooves, continued backwards as ridges[3]. Orbits moderate or large, posterior. Temporal depressions passing backwards from orbits[4]. No postarticular process to mandible[5]. Teeth unequal, clustered.

* *Teeth with large anterior and posterior cutting-edges.*

15. Loxomma, *Huxley.*

** *Teeth conical.*

16. Zygosaurus, *D'Eichwald.*
17. Melosaurus, *Von Meyer.*

IV. Athroödonta. Maxillary teeth wanting. Vomerine teeth aggregated. Orbit imperfect.

18. Batrachiderpeton, *Hancock & Atthey.*
19. Pteroplax, *Hancock & Atthey*[6].

[V. An uncharacterized group for the reception of some or all of the following genera.]

20. Pholidogaster, *Huxley.*
21. Ichthyerpeton, *Huxley.*
22. Pholiderpeton, *Huxley.*

[1] Orbits unknown.

[2] The name of *Malacocyla* was previously proposed for this section. The name, however, is inappropriate for *Melosaurus*, which we have since seen reason to associate with *Loxomma* and *Zygosaurus*.

[3] Unknown in *Melosaurus*.

[4] *Loxomma, Zygosaurus.*

[5] *Loxomma, Melosaurus.*

[6] The vomerine teeth are unknown, and this genus may therefore require to be removed.

VI. ARCHEGOSAURIA, *Von Meyer.* Vertebral column notochordal. Occipital condyles unossified.

23. Archegosaurus, *Goldfuss.*

B. *Centra of dorsal vertebræ elongate, contracted in the middle.*—Genera 24 to 31.

VII. HELEOTHREPTA. Skull triangular, with produced, tapering snout. Orbits central. Mandibular symphysis very long, about $\frac{1}{3}$ of the length of the skull.

24. Lepterpeton, *Huxley.*

VIII. NECTRIDEA. Epiotic cornua much produced. Superior and inferior processes of caudal vertebræ dilated at the extremities and pectinate.

25. Urocordylus, *Huxley.*
26. Keraterpeton, *Huxley.*

IX. AÏSTOPODA. Limbs wanting.

27. Ophiderpeton, *Huxley.*
28. Dolichosoma, *Huxley.*

X. MICROSAURIA, *Dawson.* Thoracic plates unknown. Ossification of limb-bones incomplete. Dentine nearly or altogether non-plicate; pulp-cavity large.

29. Dendrerpeton, *Owen.*
30. Hylonomus, *Dawson.*
31. Hylerpeton, *Owen.*

DESCRIPTION OF GENERA AND SPECIES.

I. EUGLYPTA.

Mastodonsaurus, Jäger.

Salamandroides, Jäger.
Labyrinthodon (part.), Owen.

Skull (figure). Triangular, broad, sides slightly concave (in the uncompressed skull) near the orbits; snout obtuse. *Orbits.* Oval, narrowed and pointed in front, moderate, somewhat posterior, approximated. *Palatine foramina.* Large, broadest near the middle, approximated. *External nasal foramina.* Small, roundish, separated by a distance about equal to the interorbital space. *Choanæ.* Roundish oval, distant, posterior to external nasal foramina. *Teeth* (disposition). Premaxillary apparently 8 or 10 on each side, larger than maxillary; maxillary very numerous, small, diminishing in size behind; palato-vomerine, two or more tusks in front of the choana, two behind it, succeeded by a few small teeth; a row of small teeth internal to these, which is continued transversely across the fore part of the united vomers; mandibular a nearly uniform series; one or two tusks form a short inner row near the symphysis. *Teeth* (structure). Conical, pointed, externally striate, with a thin investment of enamel above; dentine much complicated; pulp-cavity with sinuous and branching extensions. *Mandibular articulation.* A strong internal articular buttress; postarticular process well developed. *Cranial sculpture.* Radiate pits and grooves upon each ossification; an oval lyra commencing in the interorbital space, expanding upon the face; in the premaxillary region the two grooves suddenly take a parallel and longitudinal direction, passing between the external nasal foramina; maxillary and malar grooves; on the mandible there is an alveolar groove and a descending angular groove, which disappears near the angle of the jaw. *Thoracic plates.* Median plate rhomboidal, with four concave borders; lateral plates triangular, the postero-lateral angle being produced backwards and reflected; outer surface of all three strongly and radiately sculptured. *Vertebræ.* Centra discoidal, biconcave, well ossified. *Ribs.* Some of the ribs in the dorsal region are long, stout, compressed in the antero-posterior direction towards the head, curved and bicipital. *Limbs.* The osseous elements of the limbs are dilated at the ends, and contracted in the middle, differing from each other chiefly in size.

M. GIGANTEUS, Jäger (*M. Jägeri*, Alberti).

Interorbital space much less than transverse diameter of orbit. Parietal foramen round, in the middle of the parietal suture. Choana roundish. Palatine foramen bluntly angulated at its anterior extremity. Teeth regularly conical, slightly curved, striate, except at the apex, an additional series of alternate and equal striæ being intercalated towards the base.

The largest known Labyrinthodont.

Measurements. (From a fragment figured by Von Meyer, 'Saurier des Muschelkalkes,' t. lviii.)

	in.
Width of palatine foramen	4·8
Least distance between palatine foramina	2·56
Extent of mandibular symphysis	3
Greatest length of palato-vomerine tusks (about)	4
Diameter of largest palato-vomerine tusk	1·5

(From the Gaildorf specimen in the Stuttgard Museum.)

Total length of skull	30·5
Length of skull along middle line	23·625
Greatest breadth of skull	22·75
Breadth at middle of orbits	19·5
From centre of occiput to posterior end of orbit	6
From tip of snout to anterior end of orbit	13·5
Length of orbit	6·25
Width of orbit	4
Least width of interorbital space	2·5
Length of palatine foramen (about)	14
Width of palatine foramen	4·75
Least distance between palatine foramina	·5
Extent of mandibular symphysis	2
Length of postarticular process of mandible (about)	4

Locality. Lettenkohle, Gaildorf, Württemberg; Keuper Sandstone, Guy's Cliff, Warwick; Rhætic, Aust Cliff (near Bristol); Muschelkalk of Schwenningen?

References. Jäger, Fossile Reptilien welche in Württemberg aufgefunden worden sind, pp. 35, 38, t. iv. figs. 4, 5, 6, t. v. [1828].—Von Meyer, Palæologica, p. 107 [1832].—*Id.* Bullet. der Geol. Soc. in Frankreich, vol. iii. pp. 86–89. Jäger here unites the two genera *Mastodonsaurus* and *Salamandroides* [1833].—Alberti, Beitrag zu einer Monographie des Bunten Sandsteins, Muschelkalks, und Keupers, &c. p. 120 [1834].—Von Meyer and Plieninger, Paläontologie Württembergs, pp. 6, 21, 57, &c., tt. iii.–vi. fig. 1, t. vii. fig. 1, t. xii. fig. 14 [1844].—Owen, Trans. Geol. Soc. 2nd ser. vol. vi. p. 537, t. xlvii. [1842].—*Id.* Odontography, p. 195 &c., t. lxiii. fig. 1, tt. lxiv., lxv. [1840–5].—Von Meyer, Saurier des Muschelkalkes, pp. 93, 144, &c. tt. lviii., lxi. figs. 4–9, t. lxiv. figs. 1, 2, 15 [1847–55].—Alberti, Ueberblick über die Trias, &c., p. 255 [1864].—Miall, Q. J. Geol. Soc. vol. xxx. p. 430, &c., fig. 2 [1874].

M. PACHYGNATHUS, Owen.

Numerous fragments have occurred in the Keuper Sandstone of Warwick, which indicate a species of *Mastodonsaurus* considerably smaller than *M. giganteus.* The mandibular teeth are less conical than in the last-mentioned species; they preserve much of their thickness to near the apex, when they taper rapidly. Though some parts of the fossils attributed to this species throw light upon the structure of the Labyrinthodont skull, their zoological value is hitherto small, and the species cannot be regarded as thoroughly established.

References. Owen, Trans. Geol. Soc. 2nd ser. vol. vi. p. 526 &c., t. xliii. figs. 4–11, t. xliv. figs. 1–3, t. xlvi. figs. 6, 7 [1842].—Von Meyer & Plieninger, Paläontologie Württembergs, p. 36 [1844].—*Id.* Saurier des Muschelkalkes, p. 159.—Owen, Odontography, p. 205, &c., t. lxiv. B. figs. 1, 2 [1840–5].—

Miall, Q. J. Geol. Soc. vol. xxx. pp. 418, 431, &c., t. xxvi., xxvii. figs. 1, 2, 4? [1874].

M. Fürstenberganus, Von Meyer.

Differs from *M. giganteus* in its much smaller size, in the proportions and position of the palatine foramina, which are relatively larger and wider, as well as more posterior, and in the elongated choana. Von Meyer is disposed to refer it to *Trematosaurus*; but the great breadth of the fore part of the palatine foramen, and the numerous inner series of vomerine teeth, disposed as in *Mastodonsaurus*, oppose this determination. The resemblance to *Labyrinthodon* (and in some points to *Capitosaurus*) is considerable. A cast only of part of the palate is known.

Measurements.

		in.
From choana to anterior end of palatine foramen	(about)	2
From tip of snout to anterior end of palatine foramen	(about)	4·5
Length of palatine foramen	(about)	4·5
Width of palatine foramen	(about)	1·75
Least distance between palatine foramina......................		·375

Locality. Vosges Sandstone (Bunter) of Herzogenweiler.

References. Von Meyer, Jahrbuch für Mineralogie, 1847, p. 186.—*Id.* Saurier des Muschelkalkes, p. 138, t. lxiv. fig. 16.

M. Vaslenensis, Von Meyer.

Interorbital space wider than transverse diameter of orbit. Skull about one half the size of *M. giganteus*, but wider in proportion. Parietal foramen transversely oval, rather behind the centre of the parietal suture. Teeth unknown.

Locality. Vosges Sandstone (Bunter) of Wasslenheim, Lower Rhine.

References. Von Meyer, Jahrbuch für Mineralogie, 1847, p. 455.—*Id.* Saurier des Muschelkalkes, p. 136, t. lix. figs. 6, 7, 8 (skull), and t. lxiii. fig. 12 (thoracic plate ?).

To the same genus are referable some or all of the following, which are imperfectly known:—

Xestorrhytias Perrini, Von Meyer, Muschelkalk of Lüneville, and other Labyrinthodont fossils from the same locality. (Saurier des Muschelkalkes, pp. 77, 78, t. lxii. figs. 12, 13, 14.)

M. Adriani, Münst., from the Keuper of Würtzburg. (Petref. i. 1839, p. 102, t. xiii. fig. 8, and Saurier des Muschelkalkes, p. 151, t. lxiv. fig. 4.)

M. Meyeri, Münst., Muschelkalk of Rothenburg. (Jahrbuch für Mineralogie, 1834, p. 527; Saurier des Muschelkalkes, p. 93, t. lxiv. fig. 5.)

Odontosaurus Voltzii, Von Meyer, Bunter Sandstone of Sulzbad. (Mémoires de Strasbourg, p. 3, t. i. fig. 1; Saurier des Muschelkalkes, p. 136, t. lxiii. fig. 10.)

Also the remains from the Muschelkalk of Crailsheim (Saurier des Muschelkalkes, p. 91, t. lxiii. figs. 7, 8, 9, 13); of Lösau, near Baireuth (*ib.* p. 92, t. lxiv. fig. 7); of Bibersfeld (*ib.* p. 92, t. lxiii. fig. 4); of Pfiffelbach (*ib.* p. 91, t. lxii. fig. 17); and from the Lower Keuper of Gölsdorf (Paläontologie Württembergs, pp. 66, 72, t. xii. fig. 15).

Capitosaurus, Münster.

Skull (figure). Triangular, with broad and obtuse snout. *Orbits.* Small, oval, slightly convergent in front, situate far back, distant about twice the lateral diameter of one of them. *External nasal foramina.* Oval or roundish, convergent, distant. *Palatine foramina.* Large, closely approximated, expanded in front, pointed behind. *Choanæ.* Oval, marginal, about an inch behind and external to the external nasal foramina. *Teeth* (disposition). Premaxillary and maxillary, a nearly uniform series, diminishing in size behind; palato-vomerine, large tusks adjacent to choana, numerous smaller teeth on palatal; mandibular, a regular and uniform series. In *C. arenaceus* there are indications of an inner row of one or two tusks close to the symphysis; the mandibular and palatal series do not extend backwards so far as the maxillary row (in *C. robustus*). *Teeth* (structure). (*C. robustus*) Crown with small

anterior and posterior cutting-edges, which disappear with age; base transversely oval, or even oblong-rectangular, adherent to the alveolar parapet, where there is one; no central pulp-cavity visible in the adult tooth; dentine much complicated, as in *Mastodonsaurus*. *Mandibular articulation.* (*C. robustus*) Postarticular process well developed; a strong internal articular buttress; glenoid cavity transversely extended, and bounded in front by a broad recurved flange, which receives the anterior edge of a horizontal plate (formed apparently by the quadrate and pterygoid jointly), so as to prevent dislocation of the mandible backwards. In *C. arenaceus* the postarticular process is similar; the other details cannot be made out. *Cranial sculpture.* Each ossification strongly pitted towards the centre, and radiately grooved towards the circumference. *Thoracic plates.* (*C. robustus*) Median plate rhomboidal, with rounded entering angles; lateral plate not produced backwards, with strong reflected process; radiately sculptured. *Vertebræ.* Not certainly identified; those attributed to *Capitosaurus robustus* are discoidal, biconcave, very short in the antero-posterior direction.

C. ARENACEUS, Münster.

Orbits roundish. Parietal foramen transversely oval. The only skull known is smaller than any example of *C. robustus.*

Locality. Keuper of Benk, Franconia; Bunter Sandstone of Bernburg?

References. Münster, Jahrbuch für Mineralogie, 1836, p. 580.—Von Meyer, Paläontologie Württembergs, p. 10 [1844].—*Id.* Saurier des Muschelkalkes, pp. 141, 152, t. lix. figs. 3–5 [1847–55].—Burmeister, *Trematosaurus,* p. 3 [1849].

Measurements (from Von Meyer's figure).

		in.
Greatest breadth of skull		11?
From tip of snout to anterior end of orbit	(about)	14
Length of orbit		3
Width of orbit	(about)	2
Least width of interorbital space	(about)	·75
Greatest depth of mandible		2·5
Average length of mandibular teeth		·625

C. ROBUSTUS, Von Meyer.

Orbits oval. Parietal foramen round.

Locality. Keuper Sandstone of Württemberg.

References. Von Meyer & Plieninger, Paläontologie Württembergs, pp. 6, 21, 75, 76, 77, &c., t. ix. figs. 1, 2, 3, 7 [1844].—Quenstedt, Die Mastodonsaurier im Grünen Keupersandsteine Württembergs &c. *passim,* t. i. figs. 1, 3, 4, 6, t. ii., t. iii. figs. 4, 11?, 13, 15, 16, 17, 18, t. iv. (the shields and cranial bones in this plate cannot as yet be accurately determined) [1850].—Von Meyer, Saurier des Muschelkalkes, p. 146, t. lxi. fig. 10 [1847–55].

Measurements (from Quenstedt's Plates).

		in.
Total length of skull		23·5
Greatest breadth of skull		21
Breadth at middle of orbits		15
From centre of occiput to posterior end of orbit		5·5
From tip of snout to anterior end of orbit		14·2
Length of orbit		2·5
Width of orbit		1·9
Least width of interorbital space		3·875
Distance between external nasal foramina		2·4
From tip of snout to external nasal foramen	(about)	2·2
Length of palatine foramen		12·25
Width of palatine foramen		4·25
Least distance between palatine foramina		·625
Greatest depth of mandible		4·5

Pachygonia, Huxley.

The mandible upon which the above genus is founded presents the following peculiarities:—The external surface is strongly sculptured, and has mucous canals similar to those of *Mastodonsaurus.* "The outer wall of the ramus swells out, suddenly, just behind the level of the articular cavity, and the upper edge of the supra-angular process is, as it were, bent in by the development of this projection." The outer surface of the postarticular process is clearly more convex than usual, but we fail to detect in the text or woodcut of Prof. Huxley's memoir any really important difference between this part of the jaw of *Pachygonia* and the same part in *Mastodonsaurus.*" The splenial plate (of the articular bone) "exhibits minute, round, crater-like elevations." Teeth transversely oval at the base, conical above, small, regular; 15 or 16 only, in the back part of the ramus, are known.

Measurements (from Prof. Huxley's Memoir).

	in.
Greatest depth of mandible............................(about)	·875
Transverse diameter of mandibular teeth	·1
Longitudinal diameter of mandibular teeth ....(about)	·035

P. INCURVATA, Huxley.

Locality. Panchet Rocks (Triassic?), Ranigunj, Bengal.
References. Huxley, Palæontologia Indica: Part IV. On Vertebrate Fossils from the Panchet Rocks, p. 6, figs. 1, 2 [1865].

Trematosaurus, Braun.

Skull (figure). Elongate-triangular, with rounded apex; superior surface flattish, concave along the middle line. *Orbits.* Small, oval, separated by about twice the transverse diameter of one of them; margin slightly raised. *Palatine foramina.* Large, closely approximated, semielliptical, the straight sides being adjacent. *External nasal foramina.* Large, elongate-oval, separated by about twice the width of one of them. *Choanæ.* Elongate-oval, distant. *Teeth* (disposition). Premaxillary 12 to 14, the central ones larger; maxillary numerous, small, nearly uniform; palato-vomerine, two tusks in front of the choana; behind, the teeth gradually diminish from large tusks to the ordinary size of maxillary teeth; there are four small teeth internal to the choana; mandibular, outer series numerous, uniform, one or more tusks forming a short inner row close to the symphysis. *Teeth* (structure). Elliptical in section at the base, conical above, slightly recurved, striate; internal structure similar to that of *Mastodonsaurus. Mandibular articulation.* The articular surface is produced inwards beyond the plane of the ramus, but the nature of the supporting mass is not known; a well-developed postarticular process. *Cranial sculpture.* The centre of each ossification is strongly pitted, and the margin radiately sculptured. *Thoracic plates.* The median plate resembles a Latin cross, with the entering and salient angles rounded; the short (posterior) arm is radiately sculptured on the exposed surface; the rest of the plate is nearly smooth; the lateral plate has a thickened and reflected external margin, a short, notched posterior side, and a tapering anterior extremity. The sculpture is not known, but doubtless radiated from the thickened postero-external angle.

T. BRAUNII, Burmeister.

Orbits central. Palatine foramina narrowed to an acute angle, especially in front.

Locality. Bunter Sandstone of Bernburg.
References. Braun, Bericht der deutschen Naturforscher und Aerzte, Braunschweig, 1841, pp. 74, 75 [1842].—*Id.* Jahrbuch für Mineralogie, 1844, p. 569.—Von Meyer, Paläontologie Württembergs, pp. 4, 6, 7 [1844].—Burmeister, Die Labyrinthodonten aus dem bunten Sandstein von Bernburg. I. *Trematosaurus* [1849].—Von Meyer, Saurier des Muschelkalkes, p. 139, t. lxi. figs. 11, 12 [1847–55].—*Id.* Reptilien aus der Steinkohlenformation in Deutschland, pp. 111, 112 [1858].

Measurements (from Burmeister's figures).

	in.
Total length of skull	9·25
Length of skull along middle line	8·25
Greatest breadth of skull	5·125
Breadth at middle of orbits	2·9
From centre of occiput to posterior end of orbit	3·38
From tip of snout to anterior end of orbit	4
Length of orbit	·85
Width of orbit	·4
Least width of interorbital space	1·25
Distance between external nasal foramina	·375
From tip of snout to external nasal foramen	1
Length of palatine foramen	4·7
Width of palatine foramen	·9
Least distance between palatine foramina	·13
Greatest depth of mandible (about)	1·38
Length of postarticular process of mandible	1
Average length of maxillary teeth	·125
Greatest length of palato-vomerine tusks (about)	·5
Average length of mandibular teeth	·13
Greatest length of mandibular tusks (about)	·5
Diameter of largest palato-vomerine tusk	·38
Length of median thoracic plate (about)	6·9
Greatest width of median thoracic plate	3·85

T. OCELLA, Von Meyer.

This second species differs from *T. Braunii* in the somewhat broader form of the skull, in the blunt anterior end of the palatine foramen, and in the backward position of the orbit, which, instead of lying anterior to the centre of the palatine foramen, falls in its posterior half. The orbits are not, however, so far back as in *Capitosaurus*. The differences between the two species are not due to difference of age; for *T. ocella* is the smaller, and yet its distinctive peculiarities are such as increasing age would not diminish but exaggerate.

Locality. Bunter Sandstone of Bernburg.

References. Von Meyer, Jahrbuch für Mineralogie, 1848, p. 469.—*Id.* Saurier des Muschelkalkes, p. 140, t. lxi. figs. 1, 2 [1847–55].

Measurements (from Von Meyer's figures).

	in.
Greatest breadth of skull	5·4
Breadth at middle of orbits	4·2
Length of orbit	·66
Width of orbit	·6
Least width of interorbital space	1·1
Length of palatine foramen	4·25
Width of palatine foramen	1·2
Least distance between palatine foramina	3·8

Gonioglyptus, Huxley.

Skull (figure). Imperfectly known; the small part preserved agrees in its general proportions with *Trematosaurus Braunii*. *Palatine foramina.* Pointed in front, relatively more distant from each other and from the choanæ than in *Trematosaurus Braunii*. *Choanæ.* Elongate-oval, approximated. *Teeth* (disposition). What is seen of the maxillary, palatal, and maxillary series is similar to the same parts of *Trematosaurus*. *Mandibular articulation.* The articular surface is concave forwards, and produced internally beyond the vertical plane of the inner surface of the ramus; a well-defined postarticular process. *Cranial sculpture.* A conspicuous group of pits and grooves upon each ossification. Lyra with distinct angle (directed out-

wards) in front of the orbit; there is a maxillary groove, and upon the mandible a descending and a horizontal groove, as in *Mastodonsaurus*. *Thoracic plates.* A fragment of a lateral thoracic plate, which is probably referable to this genus and species, shows a radiate sculpture upon the external surface; the postero-external angle is reflected.

Measurements (from Prof. Huxley's Memoir).

		in.
Breadth at fore part of orbits		1·06
Least distance between palatine foramina and choanæ		·5
Greatest depth of mandible	(about)	·5
Length of postarticular process of mandible		·7

G. LONGIROSTRIS, Huxley.

Locality. Panchet Rocks (Triassic?), Ranigunj, Bengal.

References. Huxley, Palæontologia Indica: Part IV. On Vertebrate Fossils from the Panchet Rocks, p. 1, t. vi. figs. 1, 2, 3–8? [1865].

Metopias, Von Meyer.

Skull (figure). Triangular, with obtuse snout and somewhat convex sides; posterior border unknown. *Orbits.* Far forwards, oval, small, distant, converging in front. *External nasal foramina.* Large, oval, separated by about half the interorbital space, converging in front. *Palatine foramina.* Large, broadest in front and towards the middle, somewhat contracted behind, approximated. *Choanæ.* Directly in advance of palatine foramina, and distant about half an inch from them, oval, converging in front, more distant from each other than are the external nasal foramina, situate upwards of $1\frac{1}{2}$ in. further back. *Teeth* (disposition). Premaxillary and maxillary unknown; palato-vomerine, large tusks in series, with very numerous small teeth, a transverse row of small vomerine teeth in advance of the choanæ; mandibular imperfectly known, a few of rather large and uniform size have been found together in one example. *Teeth* (structure). Conical, dilated towards the tip, blunt, striate. *Cranial sculpture.* Strongly pitted, with radiating grooves towards the margins of the ossifications; a deep and conspicuous lyra, beginning in the interorbital space, rather behind the orbits, expanding into a nearly circular figure upon the face, and much contracted between the external nasal foramina. A well-marked malar groove*.

Measurements.

		in.
Greatest breadth of skull	(about)	12
Breadth at middle of orbits	(upwards of)	8
Length of orbit		1·6
Width of orbit		1·25
Least width of interorbital space		3·1
Distance between external nasal foramina		1·5
Length of palatine foramen		6·5
Width of palatine foramen		2·25
Least distance between palatine foramina		1
Average length of mandibular teeth	(about)	·5
Diameter of largest palato-vomerine tusk		·45

M. DIAGNOSTICUS, Von Meyer.

Locality. Lower Keuper Sandstone of Stuttgart; Rhætic of Aust Cliff, near Bristol.

References. Von Meyer & Plieninger, Paläontologie Württembergs, pp. 18, 75, &c. t. x. fig. 1, t. xi. fig. 11.—Von Meyer, Saurier des Muschelkalkes, p. 146, t. lx., t. lxi. fig. 3, t. lxiv. fig. 10.

There is a skull in the British Museum, from which part of the above description has been taken. The Rhætic example quoted is in the Bristol Museum.

* Only the internal half of this is shown in Von Meyer's figure ('Saurier des Muschelkalkes,' pl. lx.).

Labyrinthodon, Owen.

Choanæ. Large, oval, distant. *Teeth* (disposition). Maxillary, at least one large tusk, succeeded by small serial teeth; palato-vomerine, a transverse row of a few small teeth between choana and anterior palatine foramen, one or more tusks in front of choana, a short row of small teeth internal to it, the rest unknown; mandibular numerous, subequal, a short inner series of one or two tusks adjacent to the symphysis. *Teeth* (structure). Slender, tapering to the apex, somewhat elliptical at the base, conical above; the lower third is fluted; the internal structure is similar to that of *Mastodonsaurus*, but the folds of dentine are fewer in proportion to the diminished circumference of the tooth. *Cranial sculpture.* Radiate, consisting of ridges enclosing flat spaces; elsewhere tuberculate and irregular; a well-defined lyra (imperfectly preserved) and maxillary groove.

Measurements of Teeth (from Owen's 'Odontography').

	in.
Anterior mandibular tusk, diameter	·5
Posterior mandibular teeth, ,,	·125
Maxillary tusk, ,,	·2
Serial maxillary teeth, ,,	·027
Serial maxillary teeth, length (imperfect)	·12

L. LEPTOGNATHUS, Owen.

Locality. Keuper Sandstone of Warwick.

References. Owen, Trans. Geol. Soc. vol. vi. pl. ii. p. 503, pl. xliii. figs. 1–3, pl. xliv. figs. 7–9 [1842].—*Id.* Odontography, p. 207, t. lxiii. A. figs. 1, 1′, 2, 2′, 3, t. lxiii. B [1840–45].—Von Meyer, Paläontologie Württembergs, p. 36 [1844].—Miall, Q. J. Geol. Soc. vol. xxx. pp. 425, 430 [1874].

Diadetognathus, Miall.

Mandibular articulation. A large postarticular process, concave above; no internal articular buttress. *Teeth.* Much compressed, antero-posteriorly, at the base, so that in section they present the form of a rectangle, with the long sides perpendicular to the axis of the jaw; above, the teeth gradually become conical; the external surface exhibits numerous striæ, but no conspicuous ridges; the dentine is much folded, but there are many intricacies of arrangement which no folding, however complicated, can explain; no pulp-cavity is visible, but the upper part of the tooth has not yet been microscopically examined. *Cranial sculpture.* Similar to that of *Mastodonsaurus*, but less sharply defined.

D. VARVICENSIS, Miall.

Locality. Keuper Sandstone of Warwick.

References. Miall, Q. J. Geol. Soc. vol. xxx. pp. 425, 432, fig. 3, t. xxvii. fig. 3, t. xxviii. [1874].

Dasyceps, Huxley.

Skull (figure). Triangular, rounded in front, slightly convex on the sides, with projecting epiotic cornua and large truncated postero-lateral expansions; a facial "fontanelle." *Orbits.* Small, round, distant, placed far back. *Palatine foramina.* Relatively small, distant. *External nasal foramina.* Small, round, distant, unusually far back. *Choanæ.* Large, oval, marginal, unusually far back. *Parietal foramen.* Large, round, but little posterior to the orbits. *Teeth.* Maxillary, "pointed, much curved, and about a quarter of an inch long, their bases having a diameter of three fortieths of an inch. They are directed outwards, their curved sides being downwards and inwards (in the natural position). They are anchylosed to the margins of the jaw, which exhibits no alveolar groove. Their bases are longitudinally striated, and they present apparently a wide pulp-cavity; but I can say nothing respecting their minute structure, as I did not feel justified in detaching any of the few which remain. Obscure traces of teeth are seen in the rest of the

alveolar margins."—*Huxley.* *Cranial sculpture.* Pitted, with the intervening ridges rising at intervals into slender truncated prominences; obscure traces of a lyra.

Measurements (from Prof. Huxley's Memoir and figures).

		in.
Length of skull along middle line		10
Greatest breadth of skull		9·3
Breadth at middle of orbits	(about)	7·5
From centre of occiput to posterior end of orbit		2·25
From tip of snout to anterior end of orbit		7·5
Length of orbit		·75
Width of orbit		·75
Least width of interorbital space		2·4
Distance between external nasal foramina		2·25
From tip of snout to external nasal foramen		3·25
Least distance between palatine foramina		2·8
Average length of maxillary teeth	(about)	·25

D. Bucklandi, Lloyd.

Locality. Permian Sandstone of Kenilworth.

Reference. Huxley, Appendix to Howell's Memoir on the Warwickshire Coalfield &c., Mem. Geol. Surv. [1859].

As to the age of the rocks in which *Dasyceps* occurs, see Howell, *ibid.* p. 32, and Ramsay, Quart. Journ. Geol. Soc. vol. xi. p. 198.

Anthracosaurus, Huxley.

Skull (figure). Triangular, with rounded anterior end, back part not known; the upper surface is flat, with a median ridge in the anterior part. *Palatine foramina.* The separate existence of these foramina is doubtful. *Choanæ.* Circular, distant. *Teeth* (disposition). The premaxillary and maxillary teeth form a somewhat irregular series, the teeth being very unequal in size and relatively few in number; there is an internal row of vomerine and palatine teeth, including large tusks in front, and diminishing in size somewhat irregularly behind; mandibular teeth unequal. *Teeth* (structure). Conical, pointed, laterally compressed and recurved towards the apex, somewhat angular at the base. "Transparent transverse sections of the teeth exhibit a singularly beautiful and complex structure. The relatively small pulp-cavity sends off primary radiating prolongations, which pass straight to the circumference of the tooth, and at a small distance from it terminate by dividing usually into two short branches, each of which gives off from its extremity a wedge-shaped pencil of coarse dentinal tubuli. These spread out from one another, and terminate in a structureless or granular layer, which forms the peripheral portion of the dentine, and, from the small irregular cavities scattered here and there through its substance, reminds one of the 'globular dentine' of the human tooth. An extension of this peripheral layer is continued towards the centre of the tooth, between every pair of primary prolongations of the pulp-cavity. The short secondary processes which are sent out from opposite sides of the primary prolongations of the pulp-cavity give off in the same way, from their ends, pencils of conspicuous dentinal tubuli, the ends of which terminate in the inward extensions of the peripheral layer. The secondary processes of adjacent primary prolongations alternate and, as it were, interlock with one another, so that the inward extension of the peripheral layer takes a sinuous course between them. A thin layer of dense and glassy enamel invests the tooth continuously, but sends no processes into its interior; and, of course, under these circumstances there can be no cement in the interior of the tooth, nor can its surface be said to be plaited or folded. It will be understood that this description gives merely the principle of arrangement of the parts of the tooth; its details could only be made intelligible by elaborate figures"*. *Mandibular articulation.* Strong, transversely elongated; a well-developed post-articular process and an internal buttress are present. *Vertebræ and ribs.* There is

* Huxley, *loc. cit.*

no proof that the vertebræ and rib figured by Prof. Huxley really belong to *Anthracosaurus*.

⁂ Professor Huxley has described a "supratemporal foramen" in the skull of *Anthracosaurus*. It occurs on both sides of the only skull yet discovered, and is of elongate-oval figure, measuring 1·3 in. × ·4 in.

A. Russelli, Huxley.

Locality. Glasgow, Newsham (Northumberland), Fenton (Staffordshire).
References. Huxley, Quart. Journ. Geol. Soc. vol. xix. p. 56, fig. 1 [1863].—Hancock and Atthey, Nat. Hist. Trans. Northumberland and Durham, vol. iv. p. 385, pl. xii. [1872].

II. BRACHYOPINA.

Brachyops, Owen.

Skull (figure). Parabolic, rather broader than long *; muzzle rounded. *Orbits*. Situate far forwards, large, oval, converging in front. *Cranial sculpture*. Faintly radiate; lyra consisting of two shallow grooves, which converge as they pass forwards from the squamosals to the posterior part of the interorbital space, thence curving outwards and again inwards in a sigmoid line; there is a trace of malar grooves.

Measurements (from Prof. Owen's Memoirs and figures).

	in.
Total length of skull	4·25
Length of skull along middle line	3·6
Greatest breadth of skull	4·75
From centre of occiput to posterior end of orbit	2·25
From tip of snout to anterior end of orbit (about)	1·2
Length of orbit	1
Width of orbit	·7
Least width of interorbital space	1·6

B. laticeps, Owen.

Locality. Jurassic (?) Sandstone of Mángali, Central India.
References. Owen, Quart. Journ. Geol. Soc. vol. x. p. 473 [1854], vol. xi. p. 37, t. ii. [1855].

[For geological details as to the Mángali Sandstone, see Hislop & Hunter, Quart. Journ. Geol. Soc. vol. x. p. 472 [1854], vol. xi. p. 345 [1855].]

Micropholis, Huxley.

Skull (figure). Parabolic; postero-lateral angles produced backwards. *Orbits*. Large, oval, occupying the middle third of the skull, converging forwards; interorbital space less than the transverse diameter of the orbit. *Nasal foramina*. Rounded, "distant less than twice their own antero-posterior diameter from the anterior edge of the orbit;" separated by an interval equal to the interorbital space. *Mandibular articulation*. Transversely elongate; postarticular process absent, or very short. *Teeth*. "Very numerous and close-set, slender, conical, sharply pointed, and either straight or concave inwards; they are stronger in the lower jaw than in the upper, and in the anterior than in the posterior part of the lower jaw."

Measurements (from Prof. Huxley's Memoir and figures).

	in.
Total length of skull (about)	1·7
Length of skull along middle line	1·4
Greatest breadth of skull	1·3

* The single example known is probably flattened by *post mortem* pressure. A median depression may be due to the same cause.

		in.
Breadth at middle of orbits, restored		1·25
From centre of occiput to posterior end of orbit		·68
From tip of snout to anterior end of orbit	(about)	·55
Length of orbit		·75
Width of orbit		·5
Least width of interorbital space		·75

M. Stowii, Huxley.

Locality. Triassic rocks at the foot of the Rhenosterberg, a branch of the Sneewbergen Range, S. Africa.

References. Huxley, Quart. Journ. Geol. Soc. vol. xv. p. 642, pl. xxi. [1859].

Rhinosaurus, Waldheim.

Skull (figure). Triangular, rounded in front, sides somewhat convex; auditory openings conspicuous, wide and deep; epiotic cornua short, broad; postero-lateral expansions large, overlapping much of the posterior part of the mandible. *Orbits.* Large (length about one fourth the length of the skull along the middle line), central, roundish, irregular, distant. *External nasal foramina.* Large, round, approximated, close to the tip of the snout. *Parietal foramen.* Large, situate in the fore part of the interparietal suture, much nearer to a line joining the posterior ends of the orbits than to the occipital border. *Teeth.* Maxillary and mandibular apparently nearly regular, smaller behind, slender, slightly compressed, conical, pointed, curved. *Cranial sculpture.* Pitted radiately; no mucous grooves visible.

*** The single skull of *Rhinosaurus* shows a round foramen (situate apparently in the fore part of the quadrato-jugal). This may be accidental, or it may represent what Prof. Huxley has called the "supratemporal foramen" in *Anthracosaurus.*

Measurements (from Fischer de Waldheim's Memoir).

		(French) in.	lines.
Total length of skull		3	5
Length of skull along middle line		2	11
Greatest breadth of skull		2	4
Breadth at middle of orbits		1	8
Length of orbit	(about)	0	9
Least width of interorbital space		0	10
Distance between external nasal foramina		0	4
Greatest depth of mandible		0	7

R. Jasikovii, Waldheim.

Locality. Oolite of Simbirsk, Russia.

References. Fischer de Waldheim, "Notice sur quelques Sauriens de l'Oolithe du Gouvernement de Simbirsk," Bull. Soc. Naturalistes de Moscou, tom. xx. pt. 1, p. 364, t. v. [1847].

Bothriceps, Huxley.

Skull (figure). Parabolic. *Orbits.* Large, oval, central, converging forwards; interorbital space greater than transverse diameter of orbit. *Nasal foramina.* Large, roundish, separated by about half the interorbital space. *Teeth.* "Very numerous and close-set, not more than one eighth of an inch long; they are conical, straight, and sharp-pointed, and their bases are expanded and marked by about twelve longitudinal folds, which extend to near the apex of the tooth." *Cranial sculpture.* Pitted closely and irregularly.

Measurements (from Prof. Huxley's Memoir and figures).

		in.
Length of skull along middle line		1·3
Greatest breadth of skull	(about)	1·3
Breadth at middle of orbits	(about)	1·75

	in.
From centre of occiput to posterior end of orbit	1·5
From tip of snout to anterior end of orbit.....................	1·25
Length of orbit	·8
Width of orbit	·6
Least width of interorbital space	·45
From tip of snout to external nasal foramen	·375

B. AUSTRALIS, Huxley.

Locality. Triassic (?) rocks of some part of Australia. Precise locality unknown.
References. Huxley, Quart. Journ. Geol. Soc. vol. xv. p. 647, pl. xxii. figs. 1, 2 [1859].

III. CHAULIODONTA.

Loxomma, Huxley.

Skull (figure). An elongated isosceles triangle, with large rounded postero-lateral expansions and short epiotic cornua; coronal tract elevated, bounded on each side by temporal depressions; auditory openings indenting considerably the upper surface. *Orbits.* Very large, irregular-oval, with cusps proceeding from the posterior part of both inner and outer margins; narrowed in front; slightly oblique, the long axes diverging forwards; edges raised; interorbital space less than the transverse diameter of the orbit. *External nasal foramina.* Oval, lateral, distant *. *Choanæ.* Marginal, distant, small, slightly posterior to the external nasal foramina. *Teeth* (disposition). Premaxillary, three or four on each side, larger than maxillary; maxillary numerous, subequal; palato-vomerine, large tusks before and behind the choanæ; mandibular very unequal, 18 to 25. *Teeth* (structure). Conical, striate, with opposite (anterior and posterior) cutting-edges; a thin layer of enamel invests the crown of the tooth, and descends low down upon the sides; the dentine forms a thick and compact internal lining to the cap of enamel in the upper half of the tooth, occupying nearly all the space, and reducing the pulp-cavity to a small flattened cylinder in the centre of the tooth; in the lower half of the tooth the pulp-cavity expands and the parietes become somewhat thinner; at the same point the dentine separates into numerous vertical lamellæ, or folds, and a peripheral layer of dentine appears; towards the base of the tooth the pulp-cavity is large, occupying about one third of the diameter; the dentinal lamellæ are numerous, irregular, rarely branched, and radiately disposed around the pulp-cavity; the peripheral layer of dentine occupies the outside of the tooth, and takes a sinuous course along the centre of each lamella; when seen in cross section, each turn of the sinuous lamella of peripheral dentine appears to be strengthened by a short outstanding process, so that the lamella itself appears to be angulated; dentinal tubules pass from the peripheral layer at right angles. *Mandibular articulation.* Shallow, transversely elongated; postarticular process wanting. *Cranial sculpture.* A honeycomb pitting covers the chief part of the skull: there is a lyra consisting of two grooves which occupy the summits of slightly elevated ridges in the preorbital tract; the grooves begin in the interorbital space, and pass forwards, diverging regularly, to the maxillo-premaxillary suture; they are connected in front by a transverse groove: short maxillary grooves; no malar grooves. *Thoracic plates* have been described as those of *Loxomma,* but without satisfactory identification. *Vertebræ.* Centra well ossified, biconcave; spinous processes broad and lofty. *Ribs.* Long, slightly curved, strong.

* In the restoration of the skull of *Loxomma* given in last year's Report (t. i.) the external nares are incorrectly placed. They are shown by Mr. Atthey's fine specimen, figured in the paper referred to below, to be external to the mucous grooves upon the premaxilla. The same paper will enable us to rectify and complete the delineation of the sutures upon the upper surface of the skull in this genus. We cannot accept Messrs. Embleton and Atthey's interpretation of the palate of *Loxomma,* which is founded upon an analogy with Crocodilia which we believe to be mistaken. The "palate-plates of the maxillaries" are true palatals, and no ectopterygoid exists in the Labyrinthodont skull. The apertures named by them "posterior nares" are probably vascular canals, and we regard the foramina marked "*Ap*" in t. v. as the true choanæ.

Measurements (from Messrs. Embleton and Atthey's Memoir and Plates).

	in.
Total length of skull ....(about)	13·5
Length of skull along middle line	11·5
Greatest breadth of skull	8
Breadth at middle of orbits..................................(about)	6
From centre of occiput to posterior end of orbit	2·5
From tip of snout to anterior end of orbit..........................	5
Length of orbit	4·5
Width of orbit	1·5
Least width of interorbital space	1·5
Distance between external nasal foramina...........................	2·75
From tip of snout to external nasal foramen........................	2
Greatest depth of mandible..	2·75
Extent of mandibular symphysis	1·75
Diameter of largest palato-vomerine tusk (longitudinal)..........	·7
" " " (transverse)............	·5
Antero-posterior depth (superficial) of largest vertebral centrum ..	·65
Greatest width of vertebral centrum	1·3
Length of longest rib preserved	7·875

L. Allmani, Huxley.

Locality. Edinburgh, Glasgow, Newsham, Broseley, Longton.

References. Huxley, Q. J. Geol. Soc. vol. xviii. p. 291 [1862].—Hancock & Atthey, Trans. Nat. Hist. Soc. Northumberland and Durham, vol. iv. pp. 201, 390 [1871].—Embleton & Atthey, Ann. Nat. Hist. ser. 4, vol. xiv. p. 38, pls. iv.-vii. [1874].

Zygosaurus, Eichwald.

Skull (figure). Triangular, with concave sides and obtuse snout; occipital border concave; skull lofty in the occipital region, falling away gradually in front and rapidly on the sides.

Eichwald remarks that "the skull is distinguished by large temporal grooves, similar to those of the Crocodilian Sauria, which serve for the reception and attachment of the temporal muscles. These are observed in the Labyrinthodonts also, but especially in the Enaliosauria, as in *Nothosaurus* and *Simosaurus.* Thus *Zygosaurus* in this respect connects the Labyrinthodonts with the Enaliosauria and Crocodilia"*.

It does not, however, appear that *Zygosaurus* is fairly comparable as to the temporal region of the skull with Crocodilia. It has doubtless wide postorbital depressions, which probably served for muscular attachment; and these depressions may have been destitute of sculpture, though in the only skull known the original surface of this and other parts has been removed by fracture. The sutures are effaced, and it is therefore impossible to say positively whether the supratemporal and postorbital ossifications, which best distinguish the upper surface of the Labyrinthodont from that of the Crocodilian skull, were present in *Zygosaurus* or not. Probably they were, and the temporal depressions of *Zygosaurus* would in this case much resemble those of *Loxomma.* There is only a distant similarity between the shallow postorbital grooves of *Zygosaurus* and the vacuities circumscribed by bone which occupy a large part of the temporal region in *Nothosaurus* and *Simosaurus.* Eichwald's remarks may refer to the depressions in the occipital tract of the skull, though nothing quite similar is found in recent Crocodilia. The state of the speci-

* "Der Schädel zeichnet sich durch grosse Schläfengruben aus, die in ähnlicher Entwicklung in den krokodilartigen Eidechsen zur Aufnahme und Befestigung der Schläfenmuskeln dienen, und auch in den Labyrinthodonten, vorzüglich aber in den Enaliosauriern, wie im *Nothosaurus* und *Simosaurus* beobachtet werden, so dass der *Zygosaurus* hierin die Labyrinthodonten mit den Enaliosauriern und Krokodiliern verbindet."—Bull. de la Soc. des Naturalistes de Moscou, tom. xxi. (1848), p. 159.

men is such that it is not clear whether these depressions represent natural cavities or fractures.

Orbits. Slightly posterior, large, irregular; interorbital space equal to transverse diameter of orbit. *Teeth* (disposition). Premaxillary, two or more teeth on each side, larger than the maxillary; maxillary about 16–18 on each side, small, uniform; palato-vomerine tusks in series with small teeth. *Teeth* (structure). Conical, strong, nearly straight; apex smooth and obtuse, base with about 20 simple, regular grooves. *Cranial sculpture.* Tuberculate, radiate?

Measurements (from Eichwald's Memoir and figures).

	in.
Total length of skull ....(about)	7
Length of skull along middle line	6
Greatest breadth of skull	5
Breadth at middle of orbits....................	4·75
From centre of occiput to posterior end of orbit	2
From tip of snout to anterior end of orbit....................	3·125
Length of orbit	1·5
Width of orbit ....(about)	1
Least width of interorbital space	1·125

Z. LUCIUS, Eichwald.

Locality. Zechstein of the Government of Perm, Russia*.

References. Eichwald, Bulletin de la Société des Naturalistes de Moscou, tom. xxi. p. 159, tt. ii., iii., iv. [1848].—Pictet, Paléontologie, vol. i. p. 550 [1853].—Eichwald, Lethæa Rossica, vol. i. pl. ii. p. 1630 [1860–61].

Melosaurus, Von Meyer.

Eurosaurus, Eichwald.

Skull (figure). Triangular, with concave sides, obtuse snout, and concave occipital border. *Orbits.* Moderate, oval, posterior, interorbital space equal to transverse diameter of orbit. *External nasal foramina.* Rather small, further back and more central than usual. *Parietal foramen* with raised edges. *Teeth.* Mandibular about 30 on each side, small behind, irregular in front, small teeth in series with very large ones; conical, slightly recurved, pointed, striate at the base. *Mandibular articulation.* Postarticular process wanting. *Cranial sculpture.* Radiately pitted. *Vertebræ*, &c. The vertebræ and limb-bones attributed to this genus by Eichwald are not proved to belong to it; and some of them differ much from the same parts of undoubted Labyrinthodont skeletons.

Measurements (from Eichwald's figure).

	in.
Total length of skull	7·75
Greatest breadth of skull....................	5·25
From centre of occiput to posterior end of orbit	2·25
From tip of snout to anterior end of orbit....................	4·9
Length of orbit	1·13
Width of orbit	·75
Least width of interorbital space	·75
Length of postarticular process of mandible....................	2·5
Greatest length of mandibular tusks	1

M. URALENSIS, Von Meyer.

Locality. Calcareous marl (Permian) of Orenburg. (The single example is now at Berlin.)

References. Von Meyer, Jahrbuch für Mineralogie, p. 298 [1859].—*Id.* Palæontographica, vol. vii. p. 90, t. x. [1859].—Eichwald, Lethæa Rossica, vol. i. pt. 2, p. 1621, t. lvii. fig. 25 [1860].

* Eichwald has identified the *Chelonia radiata* of Fischer with *Zygosaurus*; it appears much more like a fossil fish.

IV. ATHROÖDONTA.

Batrachiderpeton, Hancock & Atthey.

Skull (figure). Wide; postero-lateral expansions large, produced far backwards; maxillæ deficient; coronal bones defined by raised lines. *Number of ossifications.* No maxillæ; probably no jugals or quadrato-jugals. *Orbits.* Anterior, oval?, large?, incomplete, being bounded by bone upon the inner side only. *Choana.* Large, oval. *Parietal foramen.* Far forward, large, with raised margin. *Teeth* (disposition). Premaxillary about 9 on each side, strong, equal; palato-vomerine, a dense and large central mass of aggregated (vomerine?) teeth, with a lateral (palatine?) row in advance of the choana; mandibular about 16, in the anterior part only of each ramus. *Teeth* (structure). Conical, pointed, strong; striated and somewhat compressed towards the apex. *Cranial sculpture.* Tuberculate or rugose.

Measurements (from Messrs. Hancock and Atthey's Memoir).	in.
Total length of skull	2·3
Length of skull along middle line	1·875
Greatest breadth of skull	2·625
Average length of premaxillary teeth	·06
Average length of mandibular teeth	·06

B. lineatum, Hancock & Atthey.

Locality. Newsham (Northumberland).

References. Hancock & Atthey, Nat. Hist. Trans. Northumberland and Durham, vol. iv. p. 208 [1871].

Pteroplax, Hancock & Atthey.

Skull (figure). Spatulate, narrowed in front, with acute postero-lateral (epiotic) projections; occipital margin concave. *Number of ossifications.* There are apparently no maxillæ, lachrymals, prefrontals, postorbitals, jugals, squamosals, supratemporals, or quadrato-jugals. *Orbits.* Large, anterior, incomplete, being bounded by bone upon the inner side only. *Cranial sculpture.* Pitted, the intervening ridges imperfectly defined; irregular. *Vertebræ.* Biconcave, thick, well ossified.

The teeth and premaxilla described by Messrs. Hancock and Atthey as those of *Pteroplax* belong to *Loxomma.*

Measurements. (From Messrs. Hancock & Atthey's Memoir.)	in.
Total length of skull (imperfect)	7
Length of skull along middle line	3·75
Length of epiotic cornua (about)	1
(From specimen in the Leeds Museum.)	
Greatest breadth of skull (along occipital margin)	4
Length of epiotic cornua	1·75
Antero-posterior depth (superficial) of largest vertebral centrum	·45
Greatest width of vertebral centrum	1·3

P. cornuta, Hancock & Atthey.

Locality. Newsham (Northumberland).

References. Hancock & Atthey, Nat. Hist. Trans. Northumberland and Durham, vol. iii. p. 66, t. ii. fig. 1, vol. iv. p. 207.

[V. Uncharacterized.]

Pholidogaster, Huxley.

Skull (figure). Imperfectly shown; snout obtuse. *Teeth.* Two premaxillary teeth visible; these are conical, recurved, and strongly grooved at the base. *Thoracic*

plates. Lateral plates triangular, with a reflected process at the outer angle; radiately sculptured. *Vertebræ.* Centra completely ossified, somewhat broader than long, constricted in the middle, biconcave. *Scutes.* A ventral armour, consisting of imbricated oat-shaped scutes, occurs between the pectoral and pelvic limbs.

Measurements (from Prof. Huxley's Memoir).

	in.
Greatest breadth of skull ....(about)	5
Length of mandible	7
Length of premaxillary tooth	·2
Total length of head, trunk, and tail (slightly imperfect)	43–4

P. PISCIFORMIS, Huxley.

Locality. Edinburgh Coal-field.

References. Huxley, Q. J. Geol. Soc. vol. xviii. p. 294, t. x. figs. 1, 4 [1862].

Ichthyerpeton, Huxley.

Vertebræ. Centra discoidal; caudal vertebræ imperfectly ossified? *Ribs* (posterior dorsal region). Short, tapering. *Scutes.* A ventral shield of minute scutes disposed in a chevron pattern. *Hind limb.* "Four distinct digits, with three short and thick phalanges in each, can be distinguished; the fifth digit is not apparent."

Measurements (from Prof. Huxley's Memoir and Plate).

	in.
Antero-posterior depth (superficial) of vertebral centrum	·15
Length of 10 thoracic vertebræ	1·6

I. BRADLEYÆ, Huxley.

Locality. Jarrow Colliery, Kilkenny.

References. Huxley, "Description of Vertebrate Remains from the Jarrow Colliery, Kilkenny," Trans. Royal Irish Acad. vol. xxiv. p. 17, t. xxiii. fig. 1 [1867].

Pholiderpeton, Huxley.

Teeth (structure). Maxillary and mandibular series nearly uniform; a detached tooth of large size has been distinguished upon the same slab with a skull and vertebral column; the teeth are conical, pointed and recurved at the apex. *Cranial sculpture.* Close and irregular pitting. *Vertebræ.* Centra well ossified, discoidal, biconcave. *Ribs.* Long, stout, and curved, some bicipital. *Scutes.* A ventral armour of large bony scutes, most of which are elongate, pointed at one end and rounded at the other, with a raised central ridge.

Measurements.

	in.
Average length of maxillary teeth	·45
Antero-posterior depth (superficial) of largest vertebral centrum ..	·4
Greatest width of vertebral centrum	1·4
Length of longest rib preserved (chord)	7

P. SCUTIGERUM, Huxley.

Locality. Toftshaw, near Bradford, Yorks.

References. Huxley, Q. J. Geol. Soc. vol. xxv. p. 309, t. xi. [1869].

VI. ARCHEGOSAURIA.

Archegosaurus, Goldf.

Skull (figure). Triangular, with rounded angles, sides slightly convex. *Orbits.* Situate in the posterior half of the skull (*A. Decheni*), or about the middle (*A.

latirostris); oval, small, somewhat oblique, distant*, the pointed anterior ends converging; orbital margin raised. *Palatine foramina.* Elongate, large, adjacent, pointed in front. *External nasal foramina.* Elongate-oval, approximated. *Teeth* (disposition). Premaxillary not fewer than 8 on each side in *A. Decheni*, or 11 in *A. latirostris*; maxillary not fewer than 30, irregular, of small size, diminishing behind; palato-vomerine, two or three tusks in front of the choana, and 12 or more behind, diminishing backwards to size of maxillary teeth; mandibular, a single row of nearly uniform teeth. *Teeth* (structure). Conical, finely striate, tipped with a two-edged crown of enamel when new and small; the dentine gives off a relatively small number of converging folds, which alternate with simple, radiating extensions of the pulp-cavity. *Mandibular articulation.* Somewhat weak; postarticular process short. *Cranial sculpture.* An incomplete lyra, faintly marked; pitting radiate, obscure in young specimens. *Thoracic plates.* Rhomboidal plate further produced in advance of the centre of radiation than behind it, with a slight median ridge; lateral plates triangular, truncated behind, extending backwards a little beyond the centre of the median plate; sculpture radiate, rather obscure. *Vertebræ.* Notochordal; the superior and inferior arches are ossified, and there are also three osseous cortical plates to each vertebræ, one ventral and two lateral. *Ribs.* Short, nearly straight, extending throughout the trunk and into the caudal region. *Fore limb.* About half the length of the skull; at least four digits (number uncertain). *Hind limb.* Rather larger than fore limb (as 3 : 2 in adult specimens); at least four digits. *Scutes.* Oval, lancet-shaped, &c., imbricate; ventral armour forming a chevron pattern, which is reversed behind.

A. Decheni, Goldf. (*A. medius*, Goldf.; *A. minor*, Goldf.).

Skull nearly twice as long as broad (adult). Orbit elongate-oval.

Measurements †.

	in.
Total length of skull	1·1
Length of skull along middle line	10·9
Greatest breadth of skull	5·62
Breadth at middle of orbits	3·375
From centre of occiput to posterior end of orbit	2·55
From tip of snout to anterior end of orbit	7·5
Length of orbit	1·31
Width of orbit	·75
Least width of interorbital space	1·25
Distance between external nasal foramina	·875
From tip of snout to external nasal foramen	1·375
Greatest depth of mandible	1·5
Greatest length of mandibular tusks	·48
Length of median thoracic plate (upwards of)	7
Greatest width of median thoracic plate	2·5
Length of 8 posterior thoracic vertebræ	6

Locality. Coal-measures of Saarbrück; Coal-measures of Artinsk, Ural‡.

References. Goldfuss, Beiträge zur vorweltlichen Fauna des Steinkohlengebirges [1847].—Burmeister, Die Labyrinthodonten aus dem Saarbrücker Steinkohlengebirge (*Archegosaurus*) [1850].—Von Meyer, Reptilien aus der Steinkohlenformation in Deutschland [1858].—Jordan, "Ergänzende Beobachtungen zu der Abhandlung von Goldfuss über die Gattung *Archegosaurus*," Verh. nat. Vereins d. Preuss. Rheinlande, p. 76, t. iv. fig. 1, t. vi. [1849].—Owen, Palæontology, p. 168 [1860].—Eichwald, Lethæa Rossica, vol. i. pt. ii. p. 1633 [1860].

* That is, separated by more than the transverse diameter of one of them.

† The measurements of the skull are taken from the nearly perfect example figured by Von Meyer (Reptilien aus der Steinkohlenformation, t. A). The other measurements are from large and perfect examples of the individual parts belonging to different skeletons.

‡ Eichwald, *loc. cit.* The identification rests only upon a limb-bone, and is questionable.

A. LATIROSTRIS, Jordan.

Length of skull about once and a half the breadth. Orbit roundish oval.

Measurements (from Von Meyer, 'Reptilien' &c., t. i. fig. 1).

		in.
Length of skull along middle line	(about)	4·75
Greatest breadth of skull	(about)	4·75
Breadth at middle of orbits		3·125
From centre of occiput to posterior end of orbit		1·5
From tip of snout to anterior end of orbit	(about)	2·875
Length of orbit		·87
Width of orbit		·65
Least width of interorbital space		·75
Greatest depth of mandible		·8

Locality. Coal-measures of Saarbrück.

References. H. Jordan, "Beobachtungen &c.," Verh. d. naturf. Vereins d. Preussischen Rheinlande, vi. p. 78, t. iv. figs. 2, 3 [1849].—Burmeister, Die Labyrinthodonten aus dem Saarbrücker Steinkohlengebirge (*Archegosaurus*), p. 69, t. ii. figs. 3, 4 [1850].—Von Meyer, Jahrbuch für Mineralogie, 1854, p. 422. —*Id. ib.* 1855, p. 326.—*Id.* Reptilien aus der Steinkohlenformation in Deutschland, p. 119, tt. i., ii. figs. 1-4 [1858].

VII. HELEOTHREPTA.

Lepterpeton, Huxley.

Skull (figure). Triangular, with produced, tapering snout. *Orbits.* Central, oval, moderate. *Teeth.* "There are indications of relatively long, pointed, and slightly curved teeth, set at intervals in the upper jaw." *Mandibular symphysis.* Elongate; "the slender rami of the mandible converge towards one another to the symphysis, where they become parallel, and are united for nearly 0·3 in." *Vertebræ.* About 20 precaudal and 25 caudal vertebræ; centra elongate, narrowed in the middle; neural spines low, elongate. *Ribs.* Short and curved. *Fore limb.* Carpus unossified; manus longer than the rest of the limb. *Hind limb.* "The hind limb is pentadactyle, and has a small hallux, the other digits (each of which appears to have possessed three phalanges) being very long and slender;" tarsus unossified; pes longer than the rest of the limb. *Scutes.* Indistinct traces of a ventral armour.

Measurements (from Prof. Huxley's Memoir).

	in.
Total length of skull	·85
Length of orbit	·13
Antero-posterior depth (superficial) of average vertebral centrum	·1
Length of tail	3·15
Length of fore limb	·5
Length of hind limb	·85
Total length of head, trunk, and tail	6

L. DOBBSII, Huxley.

Locality. Jarrow Colliery, Kilkenny.

References. Huxley, "Description of Vertebrate Remains from the Jarrow Colliery, Kilkenny," Trans. Royal Irish Acad. vol. xxiv. p. 12, t. xxi. figs. 1, 2 [1867].

VIII. NECTRIDEA.

Urocordylus, Huxley.

Skull (figure). Triangular, truncated behind, with rounded snout; prominent epiotic cornua *; postero-lateral expansion angulated, but not produced as a horn †.

* These are seen in the specimen described by Messrs. Hancock and Atthey, and also in an example found by Mr. John Ward, of Longton.

† Shown in Mr. Ward's specimen.

Teeth (mandible of *U. reticulatus*). Small, slightly curved, the apices apparently abruptly pointed. *Cranial sculpture.* In *U. reticulatus* the surface of the cranial bones exhibits " a coarse reticulated structure of elevated ridges or lines, which, from the elongation of the meshes in some of the bones, have the appearance of strong, raised, parallel striæ " (Hancock & Atthey). *Thoracic plates.* Covered (in *U. reticulatus*) with " a minute reticulation of raised lines, which assume a radial disposition, as if from centres of growth " (Hancock & Atthey). *Vertebræ.* Probably 20 precaudal vertebræ, " with long and low, plate-like, neural spines, the faces of which are striated, and the edges serrated, as in *Keraterpeton* " (Huxley); about 75 caudal vertebræ, their neural spines fan-like, narrow beneath, expanded and truncated above, with distinct lateral striæ and serrated superior edges; chevron-bones similar to the caudal neural spines, but broader and shorter; " up to and including the thirty-sixth vertebra, the axes of the neural spines and subvertebral bones coincide, or are parallel, both being vertical to the long axes of the vertebræ; but in the succeeding vertebræ the axes of both incline backwards, and meet at a very obtuse angle; up to the forty-second vertebra the spines and subvertebral bones, though gradually diminishing in antero-posterior extent, retain their strong grooves and striations and their frayed or notched edges; but further backward they first taper towards their ends, and finally assume the characters of ordinary spinous processes" (Huxley). *Ribs.* " Traces of numerous, short, curved, and stout ribs are visible in the confused mass which occupies the dorsal region of the trunk " (Huxley). *Scutes.* A ventral shield composed of numerous oat-shaped scales, ·2 inch long; specimens from Kilkenny, acquired by the British Museum since the publication of Prof. Huxley's description, show that these were disposed in a chevron pattern. *Fore and hind limbs.* Pentadactyle; " the fore limb had probably two thirds the length of the hind limb " (Huxley).

Measurements. (From Prof. Huxley's Memoir.)

		in.
Antero-posterior depth (superficial) of dorsal vertebral centrum		·2
Total height of anterior caudal vertebra		·95
Length of ten caudal vertebræ (51 to 60)		1
Length of ten anterior caudal vertebræ	(nearly)	2
Length of tail	(about)	13
Total length of head, trunk, and tail	(about)	19·5

(From Mr. Ward's specimen.)

Total length of skull	·9
Length of skull along middle line	·625
Greatest breadth of skull	·65

U. Wandesfordii, Huxley.

Locality. Jarrow Colliery, Kilkenny; Longton, Staffordshire.

References. Huxley, " Description of Vertebrate Remains from the Jarrow Colliery, Kilkenny," Trans. Royal Irish Acad. vol. xxiv. p. 9, t. xx. [1867].

U. reticulatus, Hancock & Atthey.

The specific distinctness of this example is not clear.

Measurements (from Messrs. Hancock & Atthey's paper).

		in.
Length of skull along middle line		·4
Greatest breadth of skull		·5
Length of epiotic cornua		·2
Antero-posterior depth (superficial) of vertebral centrum		·1
Total height of caudal vertebral centrum		·25
Total length of head, trunk, and tail	(estimated)	4·5

Locality. Newsham Colliery, Northumberland.

References. Hancock & Atthey, Nat. Hist. Trans. Northumberland and Durham, vol. iii. p. 310 [1870].

*** The genera *Oëstocephalus* and *Ptyonius* of Cope appear to belong to *Urocordylus.* Professor Cope enumerates and distinguishes the species as under:—

PTYONIUS.

a. Abdominal rods coarser, not more than ten in ·005 m.
Median pectoral plate broad, radiate, ridged .... *P. Marshii.*

aa. Abdominal rods hair-like, fifteen or more in ·005 m.
Middle pectoral shield with radii from the centre, the principal forming a cross; form wider .... *P. Vinchellianus.*
Middle pectoral with pits at the centre, and few or no radii; form narrow. *P. pectinatus.*
Middle pectoral shield narrow, closely reticulate medially, and radiate towards the circumference; size half that of the last .... *P. serrula.*

OËSTOCEPHALUS.

I. Vertebræ elongate; fan-like caudal processes narrower. Size large; mandibular teeth of unequal lengths, with the apices turned backwards. *O. remex.*

II. Species only known from cranial bones with teeth; teeth equal, erect, with acute conic apices, eleven in ·005 m................. *O. rectidens.*

All the species from the Coal-measures of Linton, Ohio.

References. Cope, Proc. Acad. Sci. Philadelphia, 1868, p. 217, &c.—*Id.* Synopsis, Trans. American Phil. Soc. vol. xiv. p. 16, &c. [1869].—*Id.* Supplement, p. 4, &c.

Keraterpeton, Huxley.

Skull (figure). Hexagonal; prominent postero-lateral and posterior (epiotic) cornua; snout very short, obtuse. *Orbits.* Large, oval, anterior; interorbital space about equal to the transverse diameter of the orbit. *Teeth.* Mandibular minute, close-set, pointed. *Cranial sculpture.* Obscure; general surface perhaps smooth, epiotic cornua longitudinally striate. *Thoracic plates.* Form indistinct; covered with a conspicuous reticulated sculpture. *Vertebræ.* Twenty vertebræ, bearing ribs, in advance of the first caudal; centra elongate, slightly constricted in the middle; neural spines (of precaudal region) low, truncate, the sides striate, the edges serrated; distinct zygapophyses; caudal vertebræ with "broad wedge-shaped subvertebral bones, which are anchylosed to the middle of their centra," devoid of ribs; neural spines and subvertebral bones similar. *Ribs.* Twelve pairs can be counted; "it is probable, however, that all the vertebræ between the occiput and the first caudal (21) bore ribs;" "they are stout, and strongly curved, with distinct tubercula and capitula; the anterior ribs are rather larger than the posterior ones, and are equal to about three of the vertebræ in length; their ventral ends are rounded, and no traces of sternal ribs are anywhere visible; the ribs behind the posterior limbs (in their present position) are shorter than the others." *Fore limb.* Radius and ulna similar; carpus unossified; five digits, the greatest number of phalanges in any one being four; somewhat shorter than hind limb. *Hind limb.* Femur short and stout, about one third longer than the tibia and fibula, which are similar to the radius and ulna; five digits, the first with two phalanges, the rest with three. *Scutes.* Ventral shield consisting of small, elongate, imbricate scutes.

Measurements (from Prof. Huxley's Memoir and Plates).

	in.
Total length of skull, including epiotic cornua............(about)	1·5
Length of skull along middle line	1
From centre of occiput to posterior end of orbit............(about)	·5
From tip of snout to anterior end of orbit ....(about)	·3
Length of orbit	·625
Width of orbit..	·2
Least width of interorbital space	·2
Antero-posterior depth (superficial) of largest vertebral centrum (nearly)	·2
Length of 20 foremost vertebræ	3·6*
Total length of head, trunk, and tail ....(not exceeding)	10

* In the text of Prof. Huxley's Memoir, p. 7, this measurement is given as 2·75 in., but this does not agree with the figure.

K. Galvani, Huxley.

Locality. Jarrow Colliery, Kilkenny.
References. Huxley, "Description of Vertebrate Remains from the Jarrow Colliery, Kilkenny," Trans. Royal Irish Acad. vol. xxiv. p. 4, t. xix. 35

IX. AÏSTOPODA.

Ophiderpeton, Huxley.

Skull. In all the examples hitherto discovered the skull was in an unsatisfactory state of preservation. Prof. Huxley remarks concerning one of these that "the roof of the skull is broad, and has an obtuse and rounded anterior end; the ramus of the mandible is strong, and has a curved lower contour, its articular end being especially curved up." *Vertebræ.* The number may have amounted to one hundred or more; centra elongate, contracted in the middle; spinous processes low, shorter antero-posteriorly than the centra. *Ribs.* Long, nearly straight. *Limbs.* Probably wanting; no trace of fore or hind limb has occurred in any one of several specimens which have been discovered in Ireland and Northumberland. *Scutes.* A ventral shield, long and narrow, made up of elongate, imbricate, slightly curved scutes, disposed in a chevron pattern.

Measurements (from Prof. Huxley's Memoir).

	in.
Total length of the largest example (incomplete)	21
Length of middle vertebra of ditto	·25
Length of the largest skull	1·6

O. Brownriggii, Huxley (*O. nanum*, Hancock & Atthey?)*.

Locality. Jarrow Colliery, Kilkenny (*O. Brownriggii*); Newsham Colliery, Northumberland (*O. nanum*).
References. Huxley, "Description of Vertebrate Remains from the Jarrow Colliery, Kilkenny," Trans. Royal Irish Acad. vol. xxiv. p. 14, t. xxii. [1867].—Hancock & Atthey, Nat. Hist. Trans. Northumberland and Durham, vol. iii. p. 79 [1869].

Dolichosoma, Huxley.

Skull (figure). "Narrow, tapering from the occiput to the snout, so as to have the form of an isosceles triangle; the lower jaw repeats the form and general dimensions of the head, and has very slender rami" (Huxley). *Vertebræ.* Complete number unknown; about fifty in the single incomplete specimen hitherto discovered; centra stout, slightly constricted; neural spinous processes low; zygapophyses apparently well developed. *Ribs.* Slender, straight, short (hardly longer than the vertebræ), rapidly tapering. *Limb.* No trace of fore or hind limb in the single example known.

Measurements (from Prof. Huxley's Memoir).

	in.
Total length of skull	·32
Greatest breadth of skull	·13
Length of 10 anterior vertebræ	·55
Total length of head, trunk, and tail (incomplete)	3·7

D. Emersoni, Huxley.

Locality. Jarrow Colliery, Kilkenny.
References. Huxley, "Description of Vertebrate Remains from the Jarrow Colliery, Kilkenny," Trans. Royal Irish Acad. vol. xxiv. p. 16, t. xxi. fig. 3 [1867].

* Doubtfully distinct. The specimen is very imperfect, and differs chiefly in size from *O. Brownriggii*.

X. MICROSAURIA.

Dendrerpeton, Owen.

Skull (figure). Parabolic. *Orbits.* Circular, central, distant, small*. *External nasal foramina.* "Small, and near the muzzle" (Dawson). *Teeth* (disposition). Premaxillary larger than the maxillary series; palato-vomerine, a close series of teeth internal to the maxillary teeth, and larger; Dr. Dawson finds also blunt teeth attached to loose bones, which he thinks may represent the vomer; mandibular, "in the lower jaw there was a uniform series of conical teeth, not perceptibly enlarged toward the front, and an inner series of larger.... teeth...." (Dawson). *Teeth* (structure). (*D. acadianum*) "Those of the vomer are thinly walled and simple, the outer series on the maxillaries and intermaxillaries [and mandible] simple and flattened, while the inner series of teeth [in both jaws] are conical and plicated" (Dawson)†. *Cranial sculpture.* Reticulate and radiate, minute. *Vertebræ.* Centra contracted in the middle, deeply biconcave; broad transverse processes, tapering to a point at their free ends, have been found attached to some of these, and distinct zygapophyses have been observed in others; "there is a large and flattened neural spine;" "there are other [vertebræ] with long spines above and below" (Dawson). *Ribs.* "Long and curved, with an expanded head, near to which they are solid, but become hollow toward the middle" (Dawson); some, at least, have a distinct tuberculum and capitulum. *Fore limb.* Supposed by Dr. Dawson to have been as large as the hind limb or larger; "the bones were hollow.... ; the humerus, however, was a strong bone, with thick walls and a cancellated structure toward its extremities" (Dawson). *Hind limb.* The component bones, as in the fore limb, are narrowed in the centre and expanded at the ends; Dr. Dawson supposes that "the foot must have been broad, and probably suited for swimming or walking on soft mud, or both." *Scutes.* "The external scales are thin, oblique-rhomboidal, or elongated-oval, marked with slight concentric lines, but otherwise smooth, and having a thickened ridge or margin..... ; in one of the specimens the scales of the throat remain in their natural position, and are seen to be of a narrow ovate form, and arranged in imbricated rows diverging from the mesial line" (Dawson).

D. ACADIANUM, Owen.

Dr. Dawson's account of the differences between this species and *D. Oweni* is given below (see *D. Oweni*).

Measurements (from Dr. Dawson).

	in.
Total length of skull	2·75
Breadth at middle of orbits	2
Length of humerus	1·33
Length of ulna	1
Length of femur	1
Length of 11 vertebræ	2·25

Locality. South Joggins, Nova Scotia.

References. Lyell & Dawson, Q. J. Geol. Soc. vol. ix. p. 58, tt. ii., iii. [1853].—Owen, *ibid.* vol. xviii. t. ix. fig. 13, t. x. figs. 5, 6, 7 [1862].—Dawson, *ibid.* vol. xix. p. 469 [1863].—*Id.* Acadian Geology, 2nd edit. p. 362, fig. 142 [1867].

D. OWENI, Dawson.

"Differs from *D. acadianum* in the following particulars:—(1) Its much smaller size; (2) its long and hooked teeth....; (3) the greater plication of the ivory in the intermaxillary teeth (in *D. acadianum* these teeth are on the outside simple

* Larger in *D. Oweni* than in *D. acadianum*, according to Dr. Dawson.

† In Dr. Dawson's 'Air-breathers of the Coal Period' [1863], p. 61, t. vi. fig. 54, the vomerine teeth are represented as aggregated into symmetrical lateral masses, which follow the outline of the maxillaries, but are most dense towards the middle line.

almost to the base, and plicated on the inner side, while in this species they are plicated all around like the inner maxillary teeth); (4) the form of the skull, which has the orbit larger in proportion, and is also shorter and broader"*.

Locality. Coal-measures of South Joggins, Nova Scotia.

References. Owen, Q. J. Geol. Soc. vol. xviii. p. 242, t. ix. fig. 4, t. x. fig. 3 [1862].—Dawson, *ibid*. vol. xix. p. 469 [1863].—*Id*. Acadian Geology, 2nd edit. pp. 362–370, figs. 142, 143 [1867].

Hylonomus, Dawson.

Teeth (disposition). Maxillary about 30 on each side; mandibular about 40 in each ramus; "in the anterior part of the lower jaw there is a group of teeth larger than the others" (Dawson). *Teeth* (structure). Conical, sharp, "perfectly simple, hollow within, and with very fine radiating tubes of ivory" (Dawson)†. *Cranial sculpture*. The bones of the skull "are smooth on the outer surface to the naked eye, and under a lens show only delicate uneven striæ and minute dots" (Dawson). *Vertebræ*. Centra elongate, contracted in the middle; some of the superior spinous processes broad and lofty. *Ribs*. Long and curved, but some short and straight, bicipital or notched at the proximal end, hollow. *Fore limb*. "The anterior limb, judging from the fragments procured, seems to have been slender, with long toes, four or possibly five in number" (Dawson). *Hind limb*. "The thigh-bone is well formed, with a distinct head and trochanter, and the lower extremity flattened and moulded into two articulating surfaces for the tibia and fibula, the fragments of which show that they were much shorter; the toes of the hind feet have been seen only in detached joints; they seem to have been thicker than those of the fore foot ....; the limb-bones present in cross section a wall of dense bone, with elongated bone-cells surrounding a cavity now filled with brown calc-spar, and originally occupied with cartilage or marrow" (Dawson)‡. *Scutes*. The ventral surface occupied by oval bony scutes; "the bony scales differ in form from those of *Dendrerpeton*; they are also much thicker; on the inner side they are concave, with a curved ledge or thickened border at one edge; on the outer side they present concentric lines of growth" (Dawson): Dr. Dawson has also described an "ornate apparatus of horny appendages," which he supposes to have covered *H. Lyelli* above.

H. Lyelli, Dawson.

The description of the genus is that of this, the typical species.

Measurements (from Dawson's 'Acadian Geology').

	in.
Length of mandible	·7
Length of humerus	·5
Length of femur	·7
Length of tibia	·45
Length of longest rib preserved (chord)	·6

Locality. Coal-measures of South Joggins, Nova Scotia.

References. Owen, Q. J. Geol. Soc. vol. xviii. p. 238, t. ix. figs. 1–6, 14 [1862].—Dawson, *ibid*. vol. xix. p. 473 [1863].—*Id*. Acadian Geology, 2nd, edit. p. 370, fig. 144 [1867].

* Dawson, 'Acadian Geology,' 2nd edit. p. 368.

† In Dr. Dawson's 'Air-breathers of the Coal Period' [1863], p. 61, t. vi. fig. 54, a patch of "palatal" (vomerine?) teeth is shown in the centre of the palate and far forward.

‡ "All the long bones, even the ribs, are hollow; and the cavity is enclosed by a compact wall of almost uniform thinness throughout each bone, indicative that such cavity was not properly a medullary one, in the sense of having been excavated by absorption after complete consolidation of the bone by the ossifying process, but was posthumous, and due to the solution of the primitive cartilaginous mould of the bone, which had remained unchanged by ossification in the living species. I conclude, therefore, that these hollow long bones (and, indeed, the bodies of the vertebræ seem only to have received a partial and superficial crust of bone) were originally solid, and composed, like the bones in most *Batrachia*, especially the Perennibranchiates, of an external osseous crust, enclosing solid cartilage."—Owen, Q. J. Geol. Soc. vol. xviii. p. 238 [1862].

H. ACIEDENTATUS, Dawson.

About twice as large as the last species. "Its teeth are very different in form. Those on the maxillary and lower jaw are stout and short, placed in a close and even series on the inner side of a ridge or plate of bone. Viewed from the side they are of a spatulate form, and present a somewhat broad edge at top.... Viewed in the opposite direction they are seen to be very thick in a direction transverse to that of the jaw, and are wedge-shaped. There are about forty on each side of the mandible, and about thirty on each maxillary" (Dawson). Pulp-cavity relatively smaller than in *H. Lyelli.*

Locality. Coal-measures of South Joggins, Nova Scotia.

References. Owen, Q. J. Geol. Soc. vol. xviii. p. 239, t. ix. figs. 7 *a*, 9 [1862].—Dawson, Acadian Geology, 2nd edit. p. 376, fig. 145 [1867].

H. WYMANI, Dawson.

Teeth bluntly conical, and fewer in number than in the other species. The remains hitherto found have belonged to very small individuals, not exceeding 4 or 5 inches in length. They are too scanty to admit of precise definition of the species.

Locality. Coal-measures of South Joggins, Nova Scotia.

References. Owen, Q. J. Geol. Soc. vol. xviii. p. 240, t. ix. figs. 8, 11, 12 [1862].—Dawson, *ibid.* vol. xix. p. 471 [1863].—*Id.* Acadian Geology, 2nd edit. p. 378, fig. 146 [1867].

Hylerpeton, Owen.

Teeth. Relatively larger than in *Hylonomus* or *Dendrerpeton,* conical-pointed; dentine non-plicate.

Fragments of ribs, a few centra of caudal (?) vertebræ, the bones of a foot, and a few ovate bony scales are attributed to the same genus by Dr. Dawson.

H. DAWSONI, Owen.

Locality. South Joggins, Nova Scotia.

References. Owen, Q. J. Geol. Soc. vol. xviii. p. 241, t. ix. fig. 16.—Dawson, Acadian Geology, 2nd edit. p. 380, fig. 147 [1867].

ANALYSIS OF CHARACTERS OF LABYRINTHODONT GENERA.

Skull elongate; length more than once and a half the greatest breadth.

Trematosaurus, Gonioglyptus, Loxomma, Pteroplax, Archegosaurus Decheni, Lepterpeton.

Skull broad; length not more than once and a half the greatest breadth.

Mastodonsaurus, Capitosaurus, Metopias, Dasyceps, Anthracosaurus, Brachyops, Micropholis, Rhinosaurus, Bothriceps, Zygosaurus, Batrachiderpeton, Pholidogaster ?, Archegosaurus latirostris, Urocordylus*, Keraterpeton.

Skull triangular, with rounded snout.

Mastodonsaurus, Capitosaurus, Eurosaurus, Trematosaurus, Gonioglyptus, Metopias, Dasyceps, Anthracosaurus, Loxomma, Zygosaurus, Archegosaurus, Lepterpeton, Urocordylus, Dolichosoma.

Skull parabolic.

Brachyops, Micropholis, Rhinosaurus, Bothriceps, Batrachiderpeton?, Dendrerpeton.

Skull polygonal, with projecting postero-lateral cornua.

Keraterpeton.

Skull much contracted in the frontal tract, expanded and truncated behind, with postero-lateral (epiotic) cornua.

Pteroplax.

* Not including the epiotic cornua in the length of the skull.

Maxillæ deficient, premaxillæ with free termination behind.

Batrachiderpeton?, Pteroplax?

Orbit round.

Dasyceps, Rhinosaurus (irregular), Dendrerpeton.

Orbit oval.

Capitosaurus, Eurosaurus, Trematosaurus, Metopias, Brachyops, Micropholis, Bothriceps, Archegosaurus, Lepterpeton, Urocordylus, Keraterpeton.

Orbit irregular-oval.

Mastodonsaurus, Loxomma, Zygosaurus.

Orbit large; not less than one fourth of the length of the skull.

Brachyops, Micropholis, Loxomma, Keraterpeton*.

Orbit moderate; not less than one eighth of the length of the skull.

Mastodonsaurus, Eurosaurus, Rhinosaurus (nearly $\frac{1}{4}$), Bothriceps (nearly $\frac{1}{4}$), Zygosaurus (nearly $\frac{1}{4}$), Archegosaurus latirostris, Lepterpeton.

Orbit small; less than one eighth of the length of the skull.

Capitosaurus, Trematosaurus, Metopias, Dasyceps, Archegosaurus Decheni.

Orbit central.

Trematosaurus, Micropholis, Rhinosaurus, Bothriceps, Loxomma (slightly posterior), Zygosaurus (slightly posterior), Lepterpeton.

Orbit anterior.

Metopias, Brachyops, Batrachiderpeton, Keraterpeton.

Orbit posterior.

Mastodonsaurus, Capitosaurus, Eurosaurus, Dasyceps, Archegosaurus.

Interorbital space equal to transverse diameter of orbit.

Eurosaurus, Rhinosaurus, Loxomma, Keraterpeton.

Interorbital space greater than transverse diameter of orbit.

Capitosaurus, Trematosaurus, Metopias, Dasyceps, Brachyops, Bothriceps, Zygosaurus, Archegosaurus, Dendrerpeton.

Interorbital space less than transverse diameter of orbit.

Mastodonsaurus, Micropholis.

Palatine foramina large, approximate.

Mastodonsaurus, Capitosaurus, Trematosaurus, Gonioglyptus, Metopias, Archegosaurus†.

Palatine foramina small, distant.

Dasyceps, Anthracosaurus, Loxomma?

External nasal foramina relatively near.

Mastodonsaurus, Trematosaurus.

External nasal foramina relatively distant.

Capitosaurus, Metopias, Dasyceps, Micropholis, Bothriceps, Loxomma, Archegosaurus, Dendrerpeton.

External nasal foramina oval.

Trematosaurus, Metopias, Loxomma, Archegosaurus‡, Dendrerpeton§.

* Not including the epiotic cornua in the length of the skull.

† Inferred from the slenderness of the *processus cultriformis* of the parasphenoid.

‡ Or hippocrepiform.

§ Transversely oval; longitudinally oval in the rest.

External nasal foramina roundish.

Mastodonsaurus, Capitosaurus, Dasyceps, Micropholis, Rhinosaurus, Bothriceps.

Auditory opening indenting posterior margin of upper surface of skull.

Mastodonsaurus, Eurosaurus, Trematosaurus, Dasyceps?, Micropholis?, Rhinosaurus, Loxomma, Archegosaurus.

Auditory opening not indenting posterior margin of upper surface of skull.

Pteroplax, Urocordylus, Keraterpeton.

Epiotic cornua conspicuous.

Dasyceps, Loxomma, Batrachiderpeton, Pteroplax, Urocordylus, Keraterpeton.

Epiotic cornua inconspicuous or wanting.

Mastodonsaurus, Capitosaurus, Trematosaurus, Micropholis, Rhinosaurus, Archegosaurus *.

Mandible with well-developed postarticular process.

Mastodonsaurus, Capitosaurus, Eurosaurus, Pachygonia?, Trematosaurus, Gonioglyptus, Diadetognathus, Anthracosaurus?

Postarticular process of mandible inconspicuous or wanting.

Micropholis, Loxomma, Archegosaurus.

Mandible with internal articular buttress.

Mastodonsaurus, Capitosaurus, Pachygonia?, Gonioglyptus, Anthracosaurus.

Mandible without internal articular buttress.

Diadetognathus, Loxomma, Archegosaurus.

Mandibular symphysis short, not exceeding twice the vertical depth of the ramus in front.

Mastodonsaurus, Capitosaurus, Trematosaurus, Labyrinthodon, Archegosaurus, Keraterpeton.

Mandibular symphysis long, exceeding twice the vertical depth of the ramus in front.

Lepterpeton (upwards of one third the length of the skull).

Maxillary teeth wanting.

Batrachiderpeton, Pteroplax.

Maxillary teeth equal or subequal.

Mastodonsaurus, Capitosaurus, Trematosaurus, Gonioglyptus?, Dasyceps, Rhinosaurus, Zygosaurus, Pholiderpeton, Archegosaurus, Dendrerpeton.

Maxillary teeth unequal.

Labyrinthodon, Anthracosaurus, Loxomma.

A transverse row of vomerine teeth.

Mastodonsaurus, Metopias, Labyrinthodon.

Vomerine teeth aggregated.

Batrachiderpeton, Dendrerpeton †, Hylonomus †.

Mandibular teeth (outer series where there are two) equal or subequal.

Mastodonsaurus, Capitosaurus, Trematosaurus, Labyrinthodon, Diadetognathus, Batrachiderpeton, Pholiderpeton, Archegosaurus, Dendrerpeton, Hylonomus, Hylerpeton.

* In one example of *A. Decheni* the cornua are ½ in. long, the length of the skull along the middle line being 11 in.

† Dawson.

Mandibular teeth unequal.
Melosaurus, Anthracosaurus, Loxomma, Pteroplax.

One or two mandibular tusks near the symphysis, forming a short inner series.
Mastodonsaurus, Trematosaurus, Labyrinthodon.

A numerous inner series of mandibular teeth.
Dendrerpeton acadianum *.

Teeth recurved at apex.
Anthracosaurus, Rhinosaurus, Pholiderpeton, Dendrerpeton Oweni.

Teeth with anterior and posterior cutting-edges.
Loxomma.

Dentine non-plicate.
Dendrerpeton acadianum (outer premaxillary, maxillary, and mandibular series, and vomerine ? teeth)†, Hylonomus, Hylerpeton.

Dentine simply plicate.
Archegosaurus.

Dentine complex-plicate.
Mastodonsaurus, Capitosaurus, Trematosaurus, Gonioglyptus, Labyrinthodon, Diadetognathus, Anthracosaurus, Loxomma, Pteroplax.

Lyra enclosing an oval or rounded space in front of the orbits.
Mastodonsaurus, Trematosaurus, Metopias, Labyrinthodon, Brachyops.

Lyra angulated.
Gonioglyptus.

Lyra consisting of two straight or nearly straight lines, diverging in front.
Loxomma, Zygosaurus.

Lyra imperfect.
Archegosaurus.

Lyra absent.
Rhinosaurus, Pteroplax ?

Thoracic plates externally sculptured.
Mastodonsaurus, Capitosaurus ? ‡, Trematosaurus, Gonioglyptus ? ‡, Archegosaurus, Urocordylus, Keraterpeton.

Lateral thoracic plate with a reflected process.
Mastodonsaurus, Capitosaurus, Trematosaurus.

Vertebral column notochordal.
Archegosaurus.

Vertebral centra discoidal.
Mastodonsaurus, Anthracosaurus, Loxomma, Ichthyerpeton, Pteroplax, Pholiderpeton.

* Dawson.
† The inner series on the præmaxillæ, maxillæ, and mandible are described as plicated. The outer series (?) in the præmaxillæ of *D. Oweni* are described by Dr. Dawson as plicated like the inner maxillary teeth.
‡ The pectoral plates believed to belong to these genera are not certainly identified.

Vertebral centra elongate, contracted in the middle.

Lepterpeton, Urocordylus, Keraterpeton, Ophiderpeton, Dolichosoma, Dendrerpeton, Hylonomus.

Superior and inferior processes of caudal vertebræ expanded distally.

Urocordylus, Keraterpeton †.

Limbs wanting.

Ophiderpeton, Dolichosoma.

Ventral armour consisting of scutes in a chevron pattern.

a. *Chevron pattern continuous.*

Urocordylus ‡.

b. *Chevron pattern reversed behind.*

Archegosaurus.

TABLE OF DISTRIBUTION.

Abbreviations:—C. Carboniferous. P. Permian. B. Bunter. M. Muschelkalk. K. Keuper. R. Rhætic. O. Oolite.

	England.	Scotland.	Ireland.	France.	Germany.	Russia.	Central India.	South Africa.	Australia.	Nova Scotia.	United States.
Mastodonsaurus, *Jäg.*											
giganteus, *Jäg.* M.?, K., R.	*	..	..	..	*						
pachygnathus, *Owen.* K.	*										
Fürstenberganus, *Meyer.* B.	..	..	..	..	*						
vaslenensis, *Meyer.* B.	..	..	..	..	*						
species. M.	..	..	..	*							
Capitosaurus, *Münst.*											
arenaceus, *Münst.* B.?, K.	..	..	..	..	*						
robustus, *Meyer.* K.	..	..	..	..	*						
Pachygonia, *Hux.*											
incurvata, *Hux.* Triassic?	..	..	..	..	..	..	*				
Melosaurus, *Meyer.*											
uralensis, *Meyer.* P.	..	..	..	..	..	*					
Trematosaurus, *Braun.*											
Braunii, *Burm.* B.	..	..	..	..	*						
ocella, *Meyer.* B.	..	..	..	..	*						
Gonioglyptus, *Hux.*											
longirostris, *Hux.* Triassic?	..	..	..	..	..	..	*				
Metopias, *Meyer.*											
diagnosticus, *Meyer.* K., R.	*	..	..	..	*						
Labyrinthodon, *Owen.*											
leptognathus, *Owen.* K.	*										
Diadetognathus, *Miall.*											
varvicensis, *Miall.* K.	*										

† An example in the collection of the British Museum shows that the spinous processes are expanded, though not to the same extent as in *Urocordylus*.

‡ Not known to be reversed. The entire ventral armour has not been seen.

TABLE (*continued*).

	England.	Scotland.	Ireland.	France.	Germany.	Russia.	Central India.	South Africa.	Australia.	Nova Scotia.	United States.
Dasyceps, *Hux.*											
Bucklandi, *Lloyd.* P.	*										
Anthracosaurus, *Hux.*											
Russelli, *Hux.* C.	*	*									
Brachyops, *Owen.*											
laticeps, *Owen.* Jurassic?							*				
Micropholis, *Hux.*											
Stowii, *Hux.* Triassic								*			
Rhinosaurus, *Waldh.*											
Jasikovii, *Waldh.* O.						*					
Bothriceps, *Hux.*											
australis, *Hux.* Triassic?									*		
Loxomma, *Hux.*											
Allmani, *Hux.* C.	*	*									
Zygosaurus, *Eich.*											
lucius, *Eich.* P.						*					
Batrachiderpeton, *H. & A.*											
lineatum, *H. & A.*	*										
Pteroplax, *H. & A.*											
cornuta, *H. & A.*	*										
Pholidogaster, *Hux.*											
pisciformis, *Hux.* C.		*									
Ichthyerpeton, *Hux.*											
Bradleyæ, *Hux.* C.			*								
Pholiderpeton, *Hux.*											
scutigerum, *Hux.* C.	*	*									
Archegosaurus, *Goldf.*											
Decheni, *Goldf.* C.					*	?					
latirostris, *Jord.* C.					*						
Lepterpeton, *Hux.*											
Dobbsii, *Hux.* C.			*								
Urocordylus, *Hux.*											
Wandesfordii, *Hux.* C.	*		*								
reticulatus, *H. & A.* C.	*										
species. C.											*
Keraterpeton, *Hux.*											
Galvani, *Hux.* C.			*								
Ophiderpeton, *Hux.*											
Brownriggii, *Hux.* C.	?		*								
Dolichosoma, *Hux.*											
Emersoni, *Hux.* C.			*								
Dendrerpeton, *Owen.*											
acadianum, *Owen.* C.										*	
Oweni, *Daws.* C.										*	
Hylonomus, *Daws.*											
Lyelli, *Daws.* C.										*	
aciedentatus, *Daws.* C.										*	
Wymani, *Daws.* C.										*	
Hylerpeton, *Owen.*											
Dawsoni, *Owen.* C.										*	

The genera and species enumerated in the Appendix may next be tabulated, omitting such as are evidently founded in mistake or too imperfectly known for definition.

	Ireland.	Germany.	Russia.	Nova Scotia.	United States
Amphibamus, *Cope.*					
grandiceps, *Cope.* C.	..	..	..	..	*
Apateon, *Meyer.*					
pedestris, *Meyer.* C.	..	*			
Baphetes, *Owen.*					
planiceps, *Owen.* C.	..	..	..	*	
Brachydectes, *Cope.*					
Newberryi, *Cope.* C.	..	..	..	..	*
Chalcosaurus, *Meyer.*					
rossicus, *Meyer.* P. ?	..	..	*		
Cocytinus, *Cope.*					
gyrinoides, *Cope.* C.	..	..	..	..	*
Dictyocephalus, *Leidy.*					
elegans, *Leidy.* Triassic	..	..	..	..	*
Erpetocephalus, *Hux.*					
rugosus, *Hux.* C.	*				
Leptophractus, *Cope.*					
obsoletus, *Cope.* C.	..	..	..	..	*
Molgophis, *Cope.*					
macrurus, *Cope.* C.	..	..	..	..	*
Wheatleyi, *Cope.* C.	..	..	..	..	*
Oëstocephalus, *Cope.*					
remex, *Cope.* C.	..	..	..	..	*
rectidens, *Cope.* C.	..	..	..	..	*
Osteophorus, *Meyer.*					
Römeri, *Meyer.* P.	..	*			
Pariostegus, *Cope.*					
myops, *Cope.* Triassic	..	..	..	..	*
Pelion, *Wyman.*					
Lyellii, *Wyman.* C.	..	..	..	..	*
Phlegethontia, *Cope.*					
linearis, *Cope.* C.	..	..	..	..	*
serpens, *Cope.* C.	..	..	..	..	*
Ptyonius, *Cope.*					
Marshii, *Cope.* C.	..	..	..	..	*
Vinchellianus, *Cope.* C.	..	..	..	..	*
pectinatus, *Cope.* C.	..	..	..	..	*
serrula, *Cope.* C.	..	..	..	..	*
Sauropleura, *Cope.*					
longipes, *Cope.* C.	..	..		..	*
digitata, *Cope.* C.	..	..	..	..	*
Sclerocephalus, *Goldf.*					
Hauseri, *Goldf.* C.	..	*			
Tuditanus, *Cope.*					
punctulatus, *Cope.* C.	..	..	..	..	*
brevirostris, *Cope.* C.	..	..	..	..	*
radiatus, *Cope.* C.	..	..	..	..	*
obtusus, *Cope.* C.	..	..	..	..	*
mordax, *Cope.* C.	..	..	..	..	*
Huxleyi, *Cope.* C.	..	..	..	..	*

APPENDIX.

In this appendix are recorded various published genera, which are either founded upon very imperfect examples or are insufficiently described by the authors for the purposes of a classification. Hence some are not known to be Labyrinthodonts at all; others, while doubtless belonging to the order, cannot be satisfactorily placed; and a third class are of doubtful distinctness from previously published genera. The genus *Ichthyerpeton* might fairly have been placed in the appendix, for we know very little about it. The reader will regard its insertion in a provisional group (p. 166) as a mere suggestion, which may be adopted or discarded when more perfect specimens have been brought to light.

Some of the American descriptions have the air of rapid determinations published to save priority. In the absence of figures, and without an opportunity of examining specimens, we have often been unable to recognize any characters of systematic value in these genera and species. When Prof. Cope's detailed account of the Carboniferous Amphibia of Ohio shall appear*, we hope that these difficulties will be removed, and that the important Labyrinthodont fauna of the United States will then render its full service to palæontology.

Amphibamus, Cope.

Skull broad. *Orbits* large, rounded. *Præmaxillæ* each with 11 or 12 teeth. "The integument of the head was squamous. . . . .The dentition is pleurodont; the teeth are only visible on the mandible and the outer edge of the upper jaw; they are there of but one kind, small, closely set, acute-conic, not compressed, hollow, and without any inflections of the enamel" †.

The dorsal vertebræ were originally described as opisthocœlian‡, without traces of ribs or transverse processes. "The impression of a sacral vertebra is distinctly preserved." Centra of caudal vertebræ probably unossified; of the neural spinous processes of the caudal vertebræ "twelve very distinct impressions may be counted to the sacral region; the posterior are most slender, the median most elevated, the anterior lower and of greater longitudinal extent." Inferior arches were probably present in the caudal region.

"The anterior limbs were short and weak." Humerus slender, not much dilated, without condyles. Ulna and radius separate and slender. "The femur is slender, much dilated distally, slightly curved in the posterior direction, and without condyles. . . . .The tibia and fibula are one half the length of the femur, are slender, most dilated proximally. . . . .The tarsus was probably cartilaginous. . . . .The number of phalanges is 3, 3, 4, 5, 4. . . . .The terminal phalanges are elongate acute."

"A few traces indicate that the dermal integument was covered, on the anterior part of the body at least, with small and subangular scales. There have been abdominal scales arranged in narrow imbricate series, directed inward and posteriorly. Traces of plates are wanting, excepting a small fragment lying beside the cervical vertebræ."

Professor Cope believes that the iris and pigmentum nigrum of the eye are preserved in the fossil. A median lenticular vacuity is "obviously the vertical pupil of a nocturnal animal. . . . .These appearances cannot be explained on any supposition of artificial production."

"This animal combines with its Batrachian, a few Lacertilian characters, having some resemblance to Dawson's genus *Hylonomus*, and much affinity with Prof.

* Palæontology of Ohio, vol. ii. (unpublished). † Peripheral layer of dentine?

‡ This was afterwards found to be erroneous. "There were actually, however, only osseous neural arches present; and I am now decidedly of the opinion that the vertebral centra were either cartilaginous or annuliform, as in *Archegosaurus*."—Cope, Synopsis, p. 8.

Wyman's *Raniceps Lyellii*. Its squamous integument and narrow nasal roof give it the somewhat Lacertilian physiognomy, more especially Geccotian, in its broad cranium and orbits, its large marginal palpebral scales, and rather short digits. Its true affinities are indicated by the presence of two premaxillaries, with a squamoso-postorbital arch, as in Labyrinthodontia, some Batrachia Gradientia, and Crocodilia; its quadrato-jugal arch as in Labyrinthodontia and Batrachia Salientia; its posteriorly directed oblique quadratum and lack of ribs, as in Batrachia Salientia; its probably short pelvis, short separate bones of the leg and forearm; its opisthocœlian dorsal vertebræ, and long caudal neural spines, as in Batrachia Gradientia. It is, then, the type of a group intermediate between the Labyrinthodontian and Gradient Batrachians, distinguished from the former by the opisthocœlian vertebræ, absence of ribs, and pleurodont dentition; and from the latter by the scaly integument, absence of ribs, and structure of the nasal and prefrontal regions. But one genus of Salamanders, *Glossolega*, has a similar os quadrato-jugale, and but a part of one family, the Salamandridæ, the postfronto-squamosal or posterior zygomatic arch. A ribless type might, however, well exist among Gradientia, when we consider the great difference between their development in *Pleurodeles* on the one hand and *Amphiuma* on the other. From the Salientia the dentigerous mandible, squamosal arch, form of vertebræ, sacrum and extremities, &c. widely distinguish it. To the Batrachian orders Labyrinthodontia, Gradientia, Gymnophidia, and Salientia, the present may be added, under the name Xenorachia.

* * * * * * * * * * * *

"If we compare the peculiarities of this genus with those of the Batrachia of the same period, we find it to be distinguished, independently of the ordinal characters, from such genera as *Osteophorus*, *Melosaurus*, *Sclerocephalus*, *Xestorrhytias*, *Baphetes*, and *Brachyops*, by the absence of the sculpturing of the cranial bones, the lack of dermal shields, characteristic of most of these, and by the presence of cranial and palpebral scales. The crania of the first genera are much more elongate, and imitate those of some Crocodilia. Similar differences exist between the Illinois Batrachian and *Dendrerpeton* (Owen); the latter possesses also a double row of teeth. *Hylonomus* (Dawson), supposed to possess Lacertilian affinities, exhibits ribs and biconcave vertebræ. The ribs of *Telerpeton* will distinguish it also. The only genus as yet known to approach closely that under consideration has been described by Prof. J. Wyman under the name of *Raniceps*. This animal is only known from a study of the inferior aspect of a portion of the skeleton; nevertheless it is certainly different, being nearly double the size, and having relatively longer and stronger anterior limbs. The angles of the mandible appear to have been considerably more incurved than in the Illinois species. They may have belonged to the same genus; in that case the name here given will not prove superfluous, as the older appellation was previously applied to a genus of Gadid Fishes."

A. GRANDICEPS, Cope.

Locality. Coal-measures of Morris, Grundy co., Illinois.
References. Cope, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 134.—*Id.* Geol. Survey of Illinois, vol. ii. p. 135, t. xxxii.—"Synopsis of Extinct Batrachia, &c. of North America," Trans. American Phil. Soc. vol. xiv. p. 7 [1870].

Amphicœlosaurus, Barkas.

Founded upon three biconcave vertebral centra, with minute notochordal foramina.

A. TAYLORI, Barkas.

Locality. Sandstone above the High-Main Coal, Northumberland.
References. Barkas, Coal-measure Palæontology, p. 104 [1873].—Atlas of Carboniferous Fossils, t. x. figs. 234 *a*, *b*, *c* [1873].

Amphisaurus, Barkas.

This genus is apparently founded upon part of a mandible with teeth of *Anthracosaurus*.

A. AMBLYODUS, Barkas.

Locality. High-Main Coal-Shale, Northumberland.

References. Barkas, Coal-measure Palæontology, pp. 72, 91 [1873].—Atlas of Carboniferous Fossils, t. ix. fig. 192, t. x. figs. 221, 221 *a*, 222 [1873].

Anisopus, Owen.

This genus is very imperfectly known, and is probably not Labyrinthodont. (See *Rhombopholis*, p. 190.)

A. SCUTULATUS, Owen.

Locality. Keuper Sandstone of Leamington.

References. Owen, Geol. Trans. 2nd ser. vol. vi. p. 538, t. xlvi. fig. 1 [1842].—*Id.* Palæontology, p. 194 [1860].—Brit. Assoc. Report, 1873, p. 243.

Apateon, Von Meyer.

The fossil upon which this genus is founded is of considerable historical interest. Upon it was based the first distinct assertion that the Carboniferous formation yielded vertebrate remains of higher rank than those of fishes. Unfortunately the only example known is somewhat obscure. It may prove to be identical with *Archegosaurus*; if distinct, its generic characters are not yet apparent. Von Meyer considered it distinct, and remarked its minute size, the absence of thoracic plates and ribs, as well as certain differences of proportion between it and *Archegosaurus**. The imperfect state of preservation deprives these considerations of much of their weight.

A. PEDESTRIS, Von Meyer.

Locality. Brandschiefer of Münster Appel.

References. Gergens, Jahrbuch für Mineralogie, 1844, p. 49.—Von Meyer, *ib.* 1844, p. 336.—*Id.* Palæontographica, i. p. 153, t. xx. fig. 1 [1851].—*Id.* Reptilien aus der Steinkohlenformation in Deutschland, p. 123, t. xi. fig. 1 [1858].—Owen, Palæontology, p. 168 [1860].

Baphetes, Owen.

The fossil "displays accurately the contour of the fore part of the upper jaw, which was broad, obtuse, and rounded. . . . .The parts preserved include the premaxillaries, nasals, and portions of the frontal, prefrontal, and maxillary bones, the proportions and connexions of which best agree with those in the skull of the *Capitosaurus*. . . . .The premaxillaries, which show some obscure traces of a symphysial suture at the median line, anterior to the nasal or naso-palatine vacuities, extend outwards, on each side, for an extent of $2\frac{1}{2}$ inches, and there join the maxillaries. Traces of round alveoli for teeth, some of which are 2 lines in diameter, are visible on the alveolar border of the premaxillaries. The alveolar border is continued,

* "Gegen den *Archegosaurus* muss bei dem *Apateon* zunächst auffallen, dass, ungeachtet der Kleinheit des Thiers, die Wirbelsäule auf der Nebenseite liegt, dass die Kehlbrustplatten zu fehlen scheinen und dass keine Rippen wahrgenommen werden, die daher, wenn sie knöchern entwickelt waren, unmöglich von Belang seyn konnten. Der *Apateon* is ein Thier von der Grosse der auf Taf. VI. Fig. 4, 6, 7 abgebildeten Exemplare von *Archegosaurus*; allein sein Kopf war nur halb so gross als am kleinsten Exemplar Fig. 4 und verhältnissmässig breiter oder weniger spitz. Die gegenseite Entfernung der vorderen und hinteren Gliedmaassen ist dieselbe. Dabei aber ist der Oberarm und Oberschenkel gegen *Archegosaurus* länger und stärker, was insbesondere für den Oberarm gilt; und wenn die vom Becken überlieferten Knochen die Sitzbeine darstellen, so ist hervorzuheben, dass sie in *Archegosaurus* bei einem Alter, wo sie ähnliche Grösse einnehmen würden, wohl noch gar nicht knöchern entwickelt waren; die kleinsten aber, welche vorliegen, sind weniger quadratisch geformt. Das Thier konnte hienach, wenn auch seine Wirbelsäule auf embryonaler Stufe stand, nicht zu *Archegosaurus* gehört haben."—*Reptilien aus der Steinkohlenformation*, p. 124.

by the maxillary bone, for an extent of $4\frac{1}{2}$ inches beyond the premaxillaries; and this border shows still more distinct traces of alveoli, of a circular form, about a line in diameter, and rather closely set in a single series. The fore part of the orbit is very unequivocally displayed, the smooth under or inner surface of the bone forming that part being entire; and this shows the fore part of the orbit to be formed, partly by the maxillary, partly by a lachrymal or prefrontal bone in close sutural union therewith,—a structure which does not exist, to my knowledge, in any recent or fossil fish with a dentigerous superior maxillary bone. Where the substance of the bone has been detached so far as to expose the exterior layer in contact with the coal, as, *e. g.*, on the frontal and part of the prefrontal bones, the exterior surface of those bones is shown to have been impressed by subhemispheric or elliptical pits, from 1 line to $1\frac{1}{2}$ line in diameter, and with intervals of half that extent: and this coarsely pitted character agrees with that presented by the outer surface of the similarly broad and flat crania of the Labyrinthodont Batrachia, e. g. *Trematosaurus*, *Capitosaurus*, and *Labyrinthodon* proper. . . . . The traces of the nostrils are less definite and satisfactory than the remains of the orbits; but the latter appear to me to be decisive against the piscine nature of the fossil."—*Owen.*

The teeth are conical and slightly curved, grooved below, and smooth towards the tip. The peripheral dentine gives off simple, slightly undulating processes towards the centre. Pulp-cavity rather large. If, as is probable, the section here described was made in the upper part of the tooth, the structure has not a little resemblance to that of *Labyrinthodon leptognathus.*

B. PLANICEPS, Owen.

Locality. Pictou Coal-field, Nova Scotia.

References. Owen, Q. J. Geol. Soc. vol. x. p. 207, t. ix. [1853].—*Id.* Palæontology, p. 184 [1860].—Dawson, Acadian Geology, 2nd ed. pp. 328, 360, figs. 137, 141 [1867].

Brachydectes, Cope.

"This genus is indicated by two rami of a mandible and a portion of a premaxillary only. . . . . The teeth are elongate cylindric cones, with their acute tips turned a little posteriorly. The fractured ones display a large pulp-cavity. The three premaxillaries preserved are similar, but without curvature of the tips. They do not exhibit striæ or any other sculpture. So far as the remains go, the genus is nearer *Hylerpeton* than any other."

B. NEWBERRYI, Cope.

Locality. Coal-measures, Linton, Columbiana County, Ohio.

References. Cope, Proc. Acad. Nat. Sci. Philadelphia, 1868, p. 214.—*Id.* Synopsis, p. 14.—*Id.* Supplement, p. 8.

Chalcosaurus, Von Meyer.

The skull only is known. Von Meyer's description (from a photograph) is appended. The few characters furnished seem to associate *Chalcosaurus* with the *Brachyopina.*

"The skull is of nearly equal length and breadth, which amount to 150 millims., not quite half a Paris foot. The hinder part appears to be injured; the obtusely parabolic anterior end is well preserved. The regularly oval orbits are situated in the middle of the anterior half of the skull. They appear to measure 29 millims. in length and 20 millims. in breadth, and are hardly more than their own length distant from each other. The margin of the [lower] jaw is set with a single row of small teeth. Indications of sutures are present, which do not, however, suffice to determine the composition of the skull."

C. ROSSICUS, Von Meyer.

Locality. Kupfer-Sandstein of the southern side of the Obschtij-Syrt, near Orenburg.

References. Von Meyer, Palæontographica, vol. xv. p. 124, t. xxi. fig. 1 [1866].

The age of the deposit from which *Chalcosaurus* was derived is still somewhat doubtful. Murchison refers it to the Permian formation. Eichwald, Ludwig, and Geinitz dissent from this view, and regard it as either Triassic or as intermediate between the Palæozoic and Neozoic epochs. Summaries of the evidence will be found in Naumann's 'Geognosie,' 2nd ed. p. 658, and in Von Meyer's 'Palæontographica,' vol. xv. p. 98.

Cocytinus, Cope.

"Vertebra and ribs osseous; anterior limbs, thoracic shields, and abdominal armature apparently wanting. Teeth on the premaxillary bone, none on the maxillary. Hyoid elements largely developed. An axial hyal with basihyal on each side, closely united with the corresponding ceratohyal, at the end of which is an element in the position of a stylohyal. Hæmal or basal branchihyals three, the anterior two each supporting one pleural branchihyal, and the third supporting one also. The first or anterior hæmal branchihyal on the hæmal side of the ceratohyal, approaching the median line, and with elongate pleural element. Urohyal not seen."

C. GYRINOIDES, Cope.

Locality. Coal-measures, Linton, Columbiana County, Ohio.
References. Cope, Proc. American Phil. Soc. 1871, p. 177.—*Id.* Supplement, p. 16.

Colosteus, Cope.

We fail to perceive any distinctive features of this genus. "The usual three sculptured pectoral bones are present. . . . . The abdominal region is protected by a series of scales which extend obliquely forwards to the medial line, where they meet, forming chevrons. . . . . Most of the teeth are coarsely incised sulcate for perhaps their basal half. . . . . The affinities are thus obviously to *Apateon,* and it is not beyond possibility that future investigations may prove it is the same."

C. SCUTELLATUS, Newberry (= *Pygopterus scutellatus,* Newberry; *Colosteus crassiscutatus,* Cope).

C. FOVEATUS, Cope.

C. PAUCIRADIATUS, Cope.

Locality. Coal-measures, Linton, Columbiana County, Ohio.
References. Newberry, Proc. Acad. Nat. Sci. Philadelphia, 1856, p. 98.—Cope, Synopsis, p. 22.—*Id.* Supplement, p. 15.

Dictyocephalus, Leidy.

The posterior part of the upper surface of the skull is known. Dr. Leidy remarks that in the arrangement of the cranial plates *Dictyocephalus* bears considerable resemblance to *Trematosaurus.* A radiate sculpture is conspicuous. The parietal foramen is situate in the centre of the parietal suture. "The occipital outline of the skull is much less sinuous than in *Archegosaurus* and *Trematosaurus,* there being only a moderate transverse concavity on each side between the mastoid and tympanic lines, instead of a deep notch." The occipital condyles are figured as close together.

"Breadth of the specimen in its present condition, $2\frac{1}{4}$ in. Breadth of occiput outline, about $2\frac{1}{4}$ in. Length of occipitals, $4\frac{1}{2}$ lines; breadth, $3\frac{3}{4}$ lines. Length of parietals, $8\frac{1}{2}$ lines; breadth anteriorly, $3\frac{3}{4}$ lines; posteriorly, 3 lines."

The teeth figured and described as possibly those of *Dictyocephalus* appear to be Deinosaurian. The rib and "bone of the forearm" have no Labyrinthodont characters. The skull is doubtless that of a true Labyrinthodont, though we are unable to assign it a definite place in the order.

D. ELEGANS, Leidy.

Locality. Coal-field (Triassic) of Chatham County, North Carolina.
References. Emmons, American Geology, pt. vi. p. 58, figs. 31, 32 [1857].—Leidy, Proc. Acad. Nat. Sci. Philadelphia, vol. viii. p. 256 [1857].

Eosaurus, Marsh.

Two vertebral centra, about $2\frac{1}{2}$ inches in diameter, biconcave, discoidal, well-ossified. They were described as Enaliosaurian, but Prof. Huxley has suggested that they may possibly be Labyrinthodont.

E. ACADIANUS, Marsh.

Locality. South Joggins, Nova Scotia.

References. Marsh, American Journal of Sci. & Arts, vol. xxxiv. p. 1, t. i. figs. 1, 2 [1862].—*Id.* Q. J. Geol. Soc. vol. xix. p. 52 [1863] (abstract).—Huxley, Q. J. Geol. Soc. vol. xix. p. 62 [1863].—Dawson, Acadian Geology, 2nd ed. p. 382, fig. 148 [1867].

Erpetocephalus, Huxley.

Skull (figure). Parabolic?; posterior border indented by wide auditory openings. *Orbits.* Central, oval, rather large, distant. *Cranial sculpture.* Irregular, rugose; no mucous grooves distinguishable. *Teeth.* "The right ramus of the mandible exhibits a number of small sharp-pointed conical teeth, set in a single series."

E. RUGOSUS, Huxley.

Locality. Jarrow Colliery, Kilkenny.

References. Huxley, "Description of Fossil Vertebrata from the Jarrow Colliery, Kilkenny," Trans. Royal Irish Acad. vol. xxiv. p. 18, t. xxiii. fig. 2 [1867].

Eupelor, Cope.

Founded upon a pitted fragment of the upper cranial surface. The teeth originally described as those of *Eupelor* are now supposed by Prof. Cope to belong to Thecodonts.

E. DURUS, Cope (=*Mastodonsaurusdurus*, Cope).

Locality. Triassic Red Sandstone near Phœnixville, Chester County, Pennsylvania.

References. Cope, Proc. Acad. Nat. Sci. Philadelphia, 1866, p. 249.—*Id.* Synopsis, p. 25.

Eurythorax, Cope.

"Established on a large thoracic shield of peculiar form. It is a median, and exhibits broad smooth surfaces for the contact of the overlapping margins of the lateral plates. The form is subrotund, with a large excavation from the posterior margin on each side. The narrowed portion left has a convex outline. Sculpture none. The form resembles remotely the corresponding scute of *Tuditanus punctulatus*, the posterior narrow face representing the xiphisternal process of that species."

E. SUBLÆVIS, Cope.

Locality. Coal-measures, Linton, Columbiana County, Ohio.

References. Cope, Proc. American Phil. Soc. 1871, p. 177.—*Id.* Supplement, p. 15.

Labyrinthodontosaurus, Barkas.

The teeth and fragment of mandible thus named are known to us only from Mr. Barkas's description and figures. They can hardly be Labyrinthodont, but much resemble a genus of fossil fishes.

L. SIMMII, Barkas.

Locality. Low-Main Coal-Shale, Northumberland.

References. Barkas, Coal-measure Palæontology, pp. 75, 94 [1873].—Atlas of Carboniferous Fossils, t. ix. fig. 194, t. x. figs. 223, 223 *a*, 224 [1873].

Lepidotosaurus, Hancock & Howse.

There does not appear to be adequate ground for reckoning this fossil among the Labyrinthodonts.

L. Duffii, Hancock & Howse.

Locality. Magnesian Limestone (Permian) of Midderidge, Durham.
References. Hancock & Howse, Q. J. Geol. Soc. vol. xxvi. p. 556, t. xxxviii. [1870].—Reprint in Nat. Hist. Trans. Northumberland and Durham, vol. iv. p. 219, t. vi. [1871].—Brit. Assoc. Report for 1873, p. 245 [1874].

Leptognathosaurus, Barkas.

This genus is not adequately characterized by Mr. Barkas, and the figure (of a mandible with teeth) does not enable us either to identify or discriminate the fossil.

L. elongatus, Barkas.

Locality. Low-Main Coal-Shale, Northumberland.
References. Barkas, Coal-measure Palæontology, p. 160 [1873].—Atlas of Carboniferous Fossils, t. x. fig. 236 [1873].

Leptophractus, Cope.

The description of the superior surface of the skull does not yield any characters of which we can avail ourselves. "The teeth are rather distantly grooved for some distance above the base. They are of different sizes; the smaller are compressed and with fore-and-aft cutting edges. . . . . The smaller ones are close together, and their crowns are curved backwards; the larger ones are at more remote intervals; both have enlarged bases; whether both forms are in the same series I cannot determine."

"The *Leptophractus* was about as large as a medium-sized alligator."

L. obsoletus, Cope.

Locality. Coal-measures of Linton, Ohio.
Reference. Cope, Proc. Acad. Nat. Sci. Philadelphia, 1873, p. 340.

Macrosaurus, Barkas.

A vertebral column, containing 80 biconcave centra, with numerous ribs attached. "The diameters of the larger vertebræ are $2\frac{1}{2}$ in., and the diameters of the smaller $1\frac{1}{2}$ in." The fossil is doubtless Labyrinthodont, but inadequately characterized.

M. polyspondylus, Barkas.

Locality. Low-Main Coal-Shale, Northumberland.
References. Barkas, Coal-measure Palæontology, p. 57 [1873].—Atlas of Carboniferous Fossils, t. vii. [1873].

Megalerpeton, Young.

"Cranium narrower than that of *Anthracosaurus* in the proportion of 4 to 5; posterior nares between first and second pairs of tusks; pterygomaxillary apertures commence an inch behind them; mandible tapering rapidly to symphysis, coarsely pitted externally; teeth regular, equal, their base oval transversely to jaw; crown circular, blunt, slightly recurved. The vertebræ differ somewhat in proportion from those of *Anthracosaurus*; their transverse processes are oblique downwards, those of *Anthracosaurus* horizontal."

M. plicidens, Young.

"Convolutions sinuous, occupying larger part of transverse section, encroaching very much on pulp-cavity."

M. SIMPLEX, Young.

"Pulp-cavity larger; folds straight, the alternate long plicæ reaching only half-way from circumference to pulp."

Locality. Lanarkshire Coal-field.

Reference. Thomson & Young, Brit. Assoc. Report, 1869, ii. p. 101.

Megalocephalus, Barkas.

To judge from the figure, this genus is based upon the posterior part of a skull of *Loxomma.* Mr. Barkas enumerates it among the true Reptilia.

M. MACROMMA, Barkas.

Locality. Low-Main Coal-Shale, Northumberland.

References. Barkas, Coal-measure Palæontology, p. 69 [1873].—Atlas of Carboniferous Fossils, t. ix. fig. 189 [1873].

Mesosaurus, Barkas.

M. Taylori, Barkas, respecting which we have no information, is enumerated by Mr. Barkas among the Amphibia of the Northumberland Coal-field (Manual of Coal-measure Palæontology, p. 116).

Molgophis, Cope.

"The characters of this genus are:—Body long, serpentine, without dermal armature, so far as known. Vertebræ large and broad, with very prominent zygapophyses and moderate neural spines; ribs large, convex."

M. MACRURUS, Cope.

M. WHEATLEYI, Cope.

Locality. Coal-measures, Linton, Columbiana County, Ohio.

References. Cope, Proc. Acad. Nat. Sci. Philadelphia, 1868, p. 220.—*Id.* Synopsis, p. 20.—*Id.* Supplement, p. 3.

Oëstocephalus, Cope.

See UROCORDYLUS, p. 170.

Orthosaurus, Barkas.

The illustrative figure represents a skull of *Loxomma.* It is considered by Mr. Barkas a distinct genus of true Reptiles.

O. PACHYCEPHALUS, Barkas.

Locality. Low-Main Coal-Shale, Northumberland.

References. Barkas, Coal-measure Palæontology, pp. 61, 102 [1873].—Atlas of Carboniferous Fossils, t. viii. figs. 183, 184, 185, t. x. fig. 232 [1873].

Osteophorus, Von Meyer.

The upper surface only of the skull is known from an imperfect natural cast. "The total length of the skull amounts to 207 millims., the breadth to 274 millims. The length, as far as the hinder margin of the parietal tract, measures little more than the breadth. The orbits lie in the posterior half of the skull, nearer the middle than the hinder end; they are nearly circular, and not noticeably oblique in position; their transverse diameter is to the longitudinal dimension as 2 to 3. The external nasal foramina are more distant from the anterior end of the skull than from the external margin; they are somewhat less distant from each other than the orbits, while the distance between the nasal foramina and the orbits is about

two fifths of the length of the skull. The nasal foramina are set obliquely, and their length amounts to more than twice the breadth; they lie for the most part in the præmaxilla, and only behind are they bounded externally by the maxilla, internally by the nasal bone. The lachrymal is excluded from the nasal foramina as well as from the orbits." The interorbital space is equal to once and a half the transverse diameter of the orbit. The most distinctive feature which appears in Von Meyer's description of the cranial bones is the presence of an azygous internasal bone. This is a narrow slip, somewhat shorter than the frontal, which lies in its anterior half between the nasals, and in its posterior half between the frontals. Von Meyer proposes for this bone the name of "Zwischennasenstirnbein" (*internaso-frontale* or *naso-frontale*). Dugès has pointed out, in the skull of *Cœcilia*, a similarly placed bone, which he calls the ethmoid*. It is the "single frontal" of Cuvier. The "facial fontanelle" of *Dasyceps* occupies precisely the same position. The parietal foramen is situated a little behind the middle point of the parietal suture. Von Meyer remarks that if the occipital border is perfectly preserved, it must have been remarkably concave. The cranial sculpture consists of deep pits and furrows upon each bone; no evidence of mucous grooves appears. Obscure indications of an affinity with *Loxomma*, *Melosaurus*, and *Zygosaurus* may be traced in the skull of *Osteophorus*; but we are not yet able to place it satisfactorily. Of its Labyrinthodont character and its generic distinctness we have no doubt.

O. Römeri, Von Meyer.

Locality. Black Marl-slate (Rothliegende) of Löwenberg, Silesia.
References. Von Meyer, Saurier des Kupferschiefer, p. vi [1856].—*Id.* Jahrbuch für Mineralogie, 1856, p. 824.—*Id.* Zeitschrift der Deutsch. geolog. Gesellschaft, 1857, p. 61.—*Id.* Palæontographica, vol. vi. p. 99, t. xi. [1860].

Parabatrachus, Owen.

The type specimen, now in the British Museum, is believed to be the inner surface of the upper jaw of *Megalichthys*.

P. Colei, Owen.

Locality. Coal-measures, Carluke?
Reference. Owen, Q. J. Geol. Soc. vol. ix. p. 67, t. ii. [1853].

Pariostegus, Cope.

"The maxillary appears to extend posteriorly to a free termination, as in modern Salamanders, and the supratemporal bone presents a very prominent, obtuse, arched margin. This margin extends from the orbits on each side, and is inclined towards the posterior part of the cranium. There is therefore no quadrato-jugal piece." The median region of the mandible "exhibits a succession of shallow transverse notches, enclosing thirteen obtuse elevations." "The orbits are remarkably small, and situated probably near the middle of the longitudinal measurement of the cranium."

P. myops, Cope.

Locality. Coalfield (Triassic), Chatham County, N. Carolina.
References. Cope, Proc. Acad. Nat. Sci. Philadelphia, 1868, p. 211.—*Id.* Synopsis, p. 10.

Pelion, Wyman.

Originally named *Raniceps*, an appellation previously applied by Cuvier to a genus of *Acanthopterygii*.

This fossil is doubtless amphibian, but it does not exhibit indisputable Labyrinthodont characters. "The general form of the head resembles that of frogs; it is triangular, and its greatest breadth nearly equals its length." The quadrate extends backwards beyond the occiput. Præmaxillæ with "small single-pointed teeth."

* Recherches sur les Batraciens, t. xiv. fig. 92, pp. 201, 209.

"The palatine bones could not be traced. The atlas is in close apposition with the occiput, so that the articulating surfaces are not visible. The expansion of the atlas indicates, however, that two condyles probably exist. No portions of the hyoid bone or of branchial arches were recognized. The vertebræ are very imperfectly preserved, and are remarkably small in proportion to the size of the animal; and though several of them are destroyed, it is estimated that about twenty existed between the occiput and the pelvis. The transverse processes, if any exist, are not visible; nor is there evidence of ribs. . . . . A slightly raised outline appears to be the only thing to indicate a scapular arch, but there are no details of structure. The arm is better preserved, the humerus is much contracted in the middle as in Batrachians generally; the radius and ulna are separate as in Urodels, and not united as in Anoura. In consequence of the displacement or concealment of some of the phalanges, the number of fingers could not be ascertained with precision. There were certainly four, but a fifth is doubtful. It would be of great importance if a fossil should be detected with five fingers, since no existing Batrachians have more than four, while many of the supposed Batrachian footprints of the coal-formations have five. The pelvis was destroyed, but traces of the right and left femur and of the right tibia remain."

P. LYELLII, Wyman.

Locality. Coal-measures, Linton, Ohio.
References. Wyman, American Journal of Science and Arts, 2nd ser. vol. xxv. p. 158 [1858]. The description is accompanied by an outline drawing.—Cope, Synopsis, p. 9.—*Id.* Supplement, p. 9.

Phlegethontia, Cope.

"Head elongate triangular; body and tail extremely elongate, the dorsal vertebræ without ribs, and the caudals without dilated spines. No ventral armature nor limbs. . . . . Chevron bones are not observable on the caudal vertebræ. This form is a true Batrachian snake."

P. LINEARIS, Cope.

P. SERPENS, Cope.

Locality. Coal-measures, Linton, Columbiana County, Ohio.
References. Cope, Proc. American Phil. Soc. 1871, p. 177.—*Id.* Supplement, p. 2.

Ptyonius, Cope.

See UROCORDYLUS, p. 170.

Raniceps, Wyman.

See PELION, p. 189.

Rhombopholis, Owen.

A substitution for *Anisopus,* which had been previously used by Templeton for a proposed genus of Amphipodous Crustacea.
Reference. Owen, Comp. Anatomy of Vertebrates, vol. i. p. 15 [1866].

Salamandroides, Jäger.

See MASTODONSAURUS, p. 151.

Sauropleura, Cope.

"Vertebræ and ribs well developed, no fan-shaped processes of the former. Limbs four, well developed and elongate," pentadactyle. "Ventral armature of slender rods arranged *en chevron,* the angle anterior. Probably no thoracic arma-

ture. This is the most Lacertilian of the Carboniferous genera, and might almost be suspected to be a reptile were it not for the ventral armature, which is precisely that of *Oëstocephalus* and other genera. It appears to lack the thoracic shields of those genera."

S. LONGIPES, Cope.

S. DIGITATA, Cope.

Locality. Coal-Measures, Linton, Columbiana County, Ohio.
References. Cope, Proc. Acad. Nat. Sci. Philadelphia, 1868, p. 215.—*Id.* Synopsis, p. 15.—*Id.* Supplement, p. 9.

Sclerocephalus, Goldf.

The single imperfect skull known seems to belong to *Archegosaurus,* and is not improbably identical with *A. latirostris.*

S. HAUSERI, Goldf.

Locality. Coal-measures of Heimkirchen, north of Kaiserslautern, Bavaria.
References. Goldfuss, Jahrbuch für Mineralogie, &c. 1847, p. 403.—Beiträge zur vorweltlichen Fauna des Steinkohlengebirges, p. 13, t. iv. figs. 1-3 [1847].—Von Meyer, Jahrbuch für Mineralogie, &c. 1848, p. 468.—*Ib.* 1854, p. 431.—Reptilien, &c. p. 120, t. vii. fig. 9 [1858].

Strepsodontosaurus, Barkas.

We do not gather either from the text or the figure any evidence of the Labyrinthodont nature of this fossil.

S. CARINATUS, Barkas.

Locality. Low-Main Coal-Shale, Northumberland.
References. Barkas, Coal-measure Palæontology, p. 107 [1873].—Atlas of Carboniferous Fossils, t. x. fig. 237 [1873].

Tuditanus, Cope.

"Cranium broad, flat, orbits anterior, bones more or less sculptured. Teeth on premaxillary and maxillary bones of nearly equal sizes. Three pectoral shields sculptured externally. Form lizard-like; two pairs of limbs of medium proportions.' Ventral scutes unknown.

T. PUNCTULATUS, Cope; T. BREVIROSTRIS, Cope; T. RADIATUS, Cope; T. OBTUSUS, Cope (=*Dendrerpeton obtusum,* Cope); T. MORDAX, Cope; T. HUXLEYI, Cope.

Locality. Coal-measures, Linton, Columbiana County, Ohio.
References. Cope, Proc. American Phil. Soc. 1871, p. 177.—*Id.* Supplement, p. 11.

Xestorrhytias, Von Meyer.

The fragment of cranial bones from the posterior part of the skull figured in 'Saurier des Muschelkalkes' has few distinctive features. The ridges which divide the pits and furrows are flat and smooth, and the pattern of sculpture is unusually large. The generic value of the fossil cannot be asserted. It is apparently nearly allied to *Mastodonsaurus.*

X. PERRINI, Von Meyer.

Locality. Muschelkalk of Lüneville.
Reference. Von Meyer, Saurier des Muschelkalkes, p. 78, t. lxii. fig. 5 [1847–55].

EXPLANATION OF THE PLATES.

All the figures are reduced to one length. The natural dimensions are given in the text. The bones are lettered thus:—*Pmx*, Præmaxilla; *Mx*, Maxilla; *Na*, Nasal; *La*, Lachrymal; *PFr*, Prefrontal; *Fr*, Frontal; *PtFr*, Postfrontal; *Pa*, Parietal; *PtO*, Postorbital; *Sq*, Squamosal; *SO*, Supraoccipital; *Ep*, Epiotic; *Ju*, Jugal; *QJ*, Quadratojugal; *Q*, Quadrate; *Pal*, Palatal; *Vo*, Vomer; *Pt*, Pterygoid.

Plate IV.

Figs. 1, 2. Slightly altered from Von Meyer's 'Saurier des Muschelkalkes,' t. lxi. figs. 4, 5.
3, 4. Reduced from Burmeister's 'Trematosaurus,' tt. i., ii.

Plate V.

Fig. 1. Slightly altered from Von Meyer's 'Saurier des Muschelkalkes,' t. lxi. fig. 10.
2. Chiefly from specimen in the British Museum.
3. Adapted from Huxley's Appendix to Howell's "Memoir on the Warwickshire Coalfield" &c. (Mem. Geol. Survey), figs. 1, 2.
4. Adapted from Prof. Owen's figure, 'Quart. Journ. Geol. Soc.' vol. xi. t. ii.

Plate VI.

Fig. 1. From Waldheim's "Notice" &c., Bull. Soc. Naturalistes de Moscou, tom. xx. t. v.
2. Chiefly from Embleton & Atthey, 'Ann. Nat. Hist.' ser. 4, vol. xiv. t. iv.
3, 4. Adapted from Hancock & Atthey, 'Nat. Hist. Trans. Northumberland and Durham,' vol. iv. t. iv.

Plate VII.

Fig. 1. Partly from Hancock & Atthey, 'Nat. Hist. Trans. Northumberland and Durham,' vol. iii. t. ii. fig. 1. The conjectural restoration (in dotted lines) from the recent *Menopoma*.
2. Adapted from Huxley, 'Trans. Royal Irish Acad.' vol. xxiv. t. xix.
3. Reduced from Von Meyer's 'Reptilien' &c., t. A.
4. Compiled from various fragments figured by Von Meyer in the same work.

Second Report of the Committee, consisting of Professor Harkness, Prof. Prestwich, Prof. Hughes, Rev. H. W. Crosskey, Prof. W. Boyd Dawkins, Messrs. C. J. Woodward, George Maw, L. C. Miall, G. H. Morton, *and* J. E. Lee, *appointed for the purpose of recording the position, height above the sea, lithological characters, size, and origin of the more important of the Erratic Blocks of England and Wales, reporting other matters of interest connected with the same, and taking measures for their preservation. Drawn up by the* Rev. H. W. Crosskey, *Secretary.*

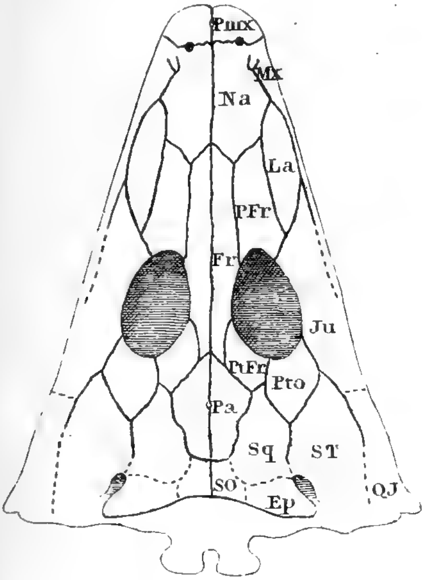
Your Committee, in fulfilment of the duty entrusted to them, prepared and distributed a schedule of questions having reference both to isolated erratic boulders and groups of boulders, defining boulders as masses of rock transported by natural agency from some locality more or less remote. The schedule was adapted from one issued by the Edinburgh Boulder Committee (quoted in the last Report); but it was thought desirable to extend its scope so as to include groups of boulders as well as isolated specimens, and to place no limit of measurement to the definition.

As far as possible also the schedule has been made complete, and the questions asked have been extended to details of considerable scientific importance.

The following is a copy of the schedule issued:—

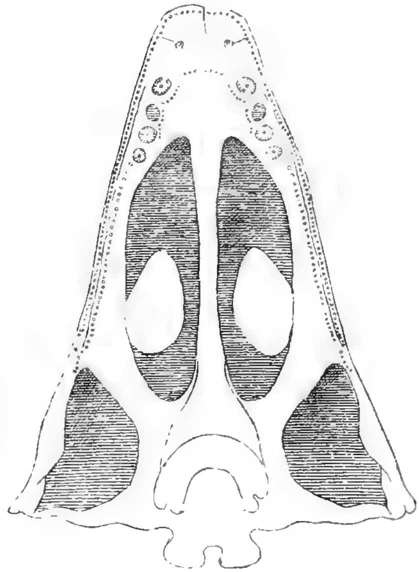
1. Mastodonsaurus.

Upper Surface.



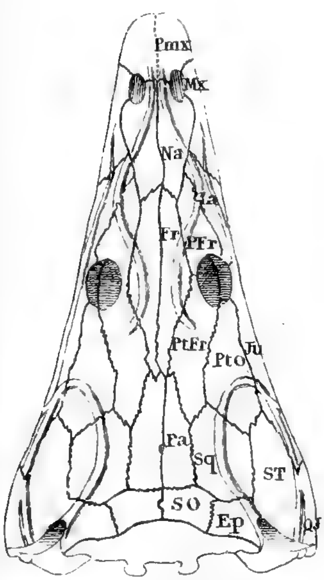
2. Mastodonsaurus.

Under Surface.



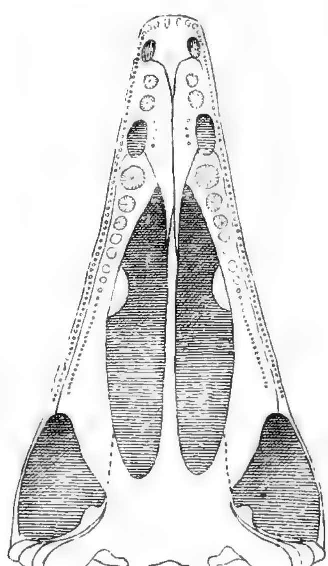
3. Trematosaurus.

Upper Surface.



4. Trematosaurus.

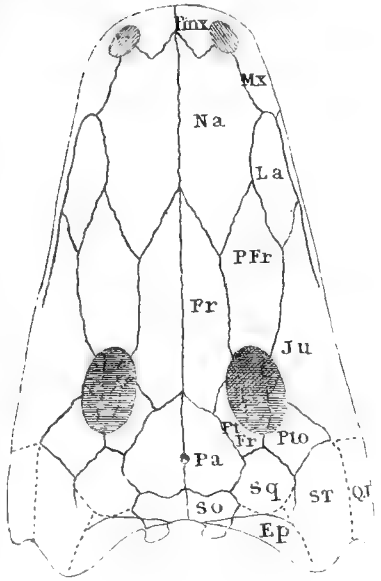
Under Surface.



Engraved by Chas. Ingram.

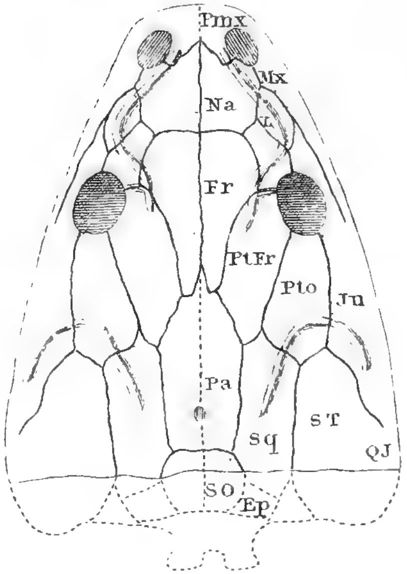
1. Capitosaurus.

Upper Surface.



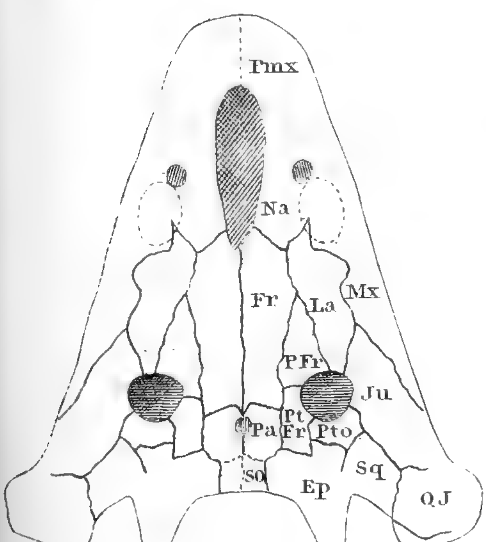
2. Metopias.

Upper Surface.



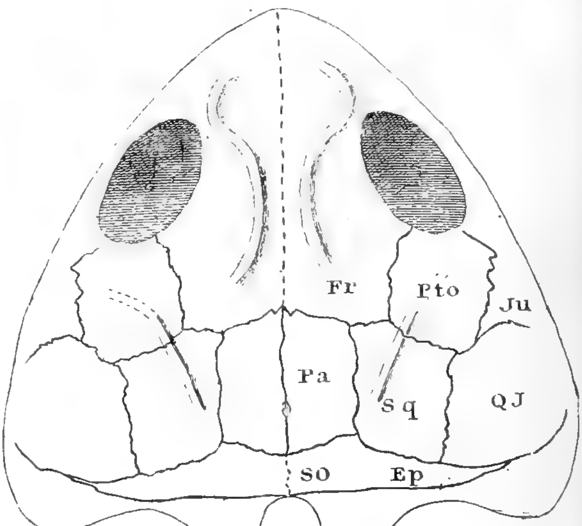
3. Dasyceps.

Upper Surface.



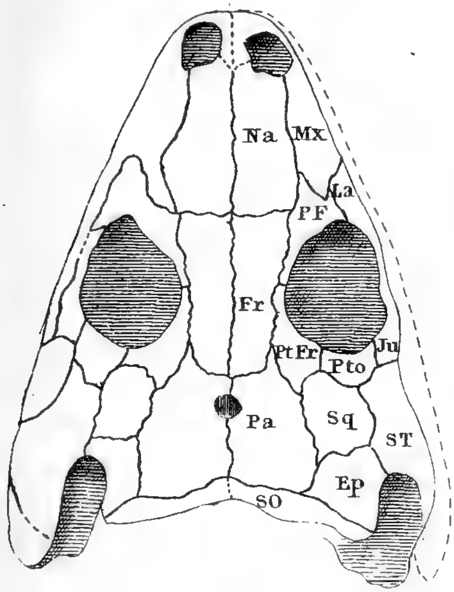
4. Brachyops.

Upper Surface.

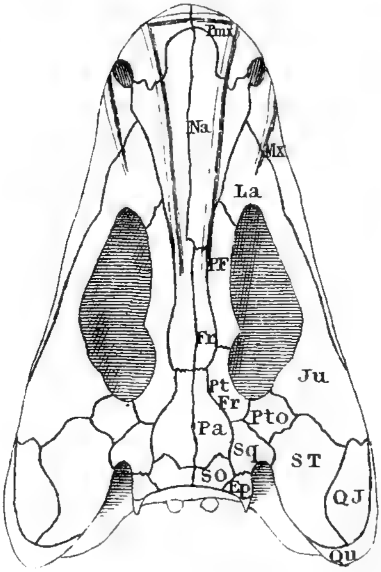


Engraved by Chas. Ingram.

1. *Rhinosaurus*

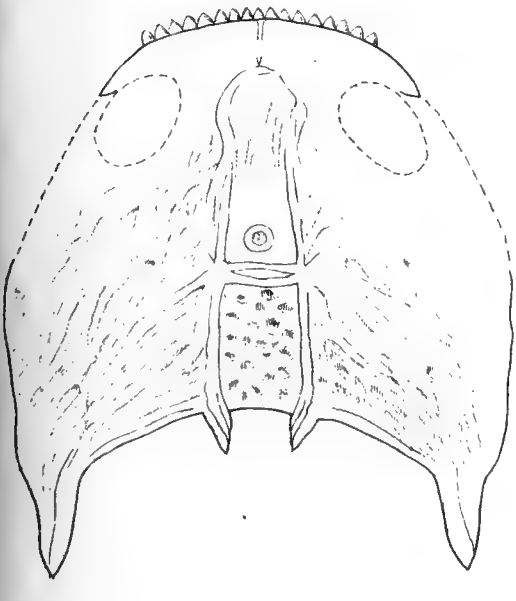


2. *Loxomma.*



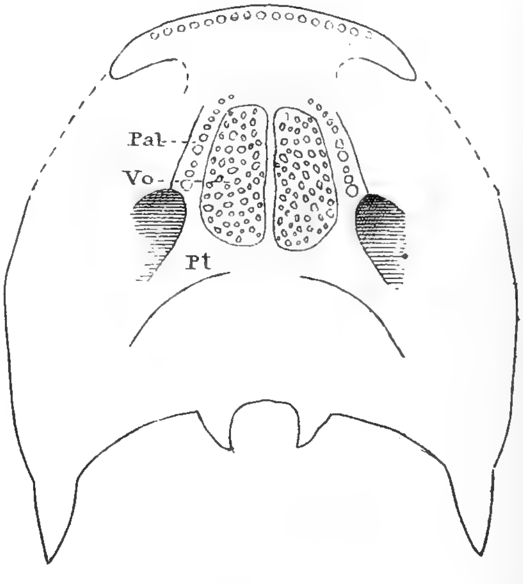
3. *Batrachiderpeton.*

Upper Surface.



4. *Batrachiderpeton.*

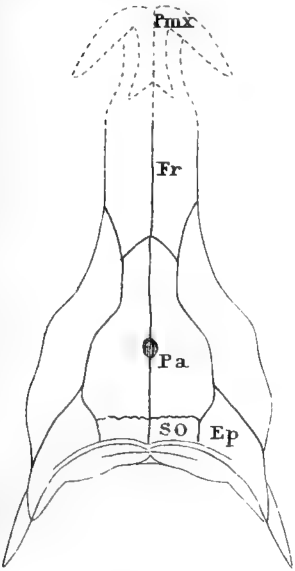
Under Surface.



Engraved by C. Ingram

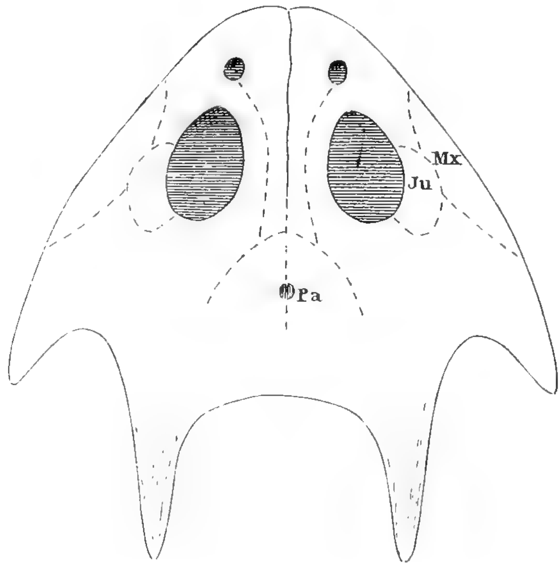
1. *Pteroplax*

Upper Surface



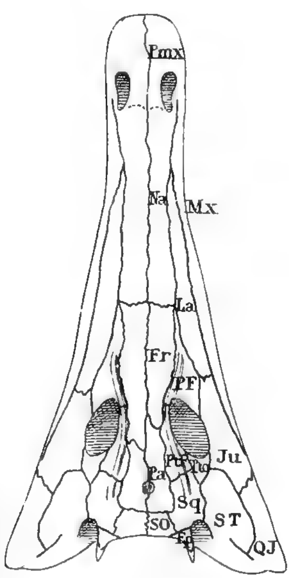
2. *Keraterpeton*

Upper Surface



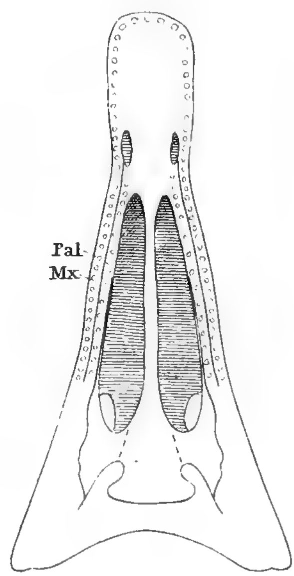
3. *Archegosaurus*

Upper Surface



4. *Archegosaurus*

Under Surface



If there are in your District any (A) Isolated Erratic Blocks *or* Boulders, *or* (B) Groups of Boulders (i. e. *masses of Rock evidently transported by natural agency from some locality more or less remote*), *please return this paper, with answers to the following Queries, to the* Rev. H. W. CROSSKEY, *Secretary to the Boulder Committee*, 28 *George Road, Birmingham.*

(A) ISOLATED BOULDERS.

Queries.	Answers.
1. What is name of the Parish, Estate, and Farm on which Boulder is situated? adding nearest Town and County, and any particular enabling its position to be marked on the Ordnance Map.	
2. What are dimensions of Boulder, in length, breadth, and height above ground?	
3. Is the Boulder rounded, subangular, or angular?	
4. If the Boulder is long-shaped, and has not been moved by man, what is direction by compass of its longest axis?	
5. If there are any natural ruts, groovings, or striations on Boulder, state— (*a*) Their lengths, depth, and number. (*b*) The part of Boulder striated, viz. whether top or sides. (*c*) Whether the striations are in the direction of the longer axis, or at what angle to it.	
6. What is the nature of the rock composing the Boulder? If it is of a species of rock differing from any rocks adjoining it, state locality where, from personal observation, you know that a rock of the same nature as the Boulder occurs, the distance of that locality, and its bearings by compass from the Boulder.	
7. If Boulder is known by any popular name, or has any legend connected with it, mention it.	
8. What is the height of Boulder above the sea?	
9. Is the Boulder indicated on any map? or does it mark any boundary of a County, Parish, or Estate?	
10. If there is any Photograph or Sketch of the Boulder, please to say how Committee can obtain it.	
11. Is the Boulder connected with any long ridges of gravel or sand, or is it isolated?	
12. On what does the Boulder rest?	

(B) GROUPS OF BOULDERS.

Though there may be no one Boulder in your district so remarkable as to deserve description, there may be Groups of Boulders.

Queries.	Answers.
1. What is the name of the Parish, Estate, and Farm on which they are situated? adding the nearest Town and County, and any particular enabling their posi- to be marked on the Ordnance Map.	
2. What are the dimensions of the smallest and largest Boulders of the group?	
3. Are the Boulders rounded, subangular, or angular?	
4. If any large Boulder of the group (which has not been moved by man) is long-shaped, what is direction by compass of its longest axis?	
5. If there are any natural ruts, grooving, or striations on any Boulder, state— (*a*) Their lengths, depth, and number. (*b*) The parts of the Boulder striated, viz. whether top or sides. (*c*) Whether the striations are in the direction of the longer axis, or at what angle to it.	
6. State (*a*) localities where rocks undoubtedly of the same nature as the Boulders occur. [*Be careful to ascertain that none of the Boulders have been brought from a distance by human agency.*] (*b*) The distances of those localities and their bearings by compass from the Boulders.	
7. What is the nature of the Rocks composing the Boulders? and in what proportions do the Boulders of the various rocks represented in the group occur?	
8. What is the height of the group above the sea?	
9. Over what area does the group extend? and what number of Boulders are there in the group or per acre?	
10. Are the Boulders exposed on the surface or are they surrounded by any deposit? Add any observations explanatory of the position in which the Boulders are found.	

The Committee have reason to believe that inquiries are being made on its behalf in many parts of the country, although the returns at present received are not sufficiently complete to admit of systematic classification. It is felt, indeed, that a classified arrangement of the facts can only be attempted when the investigation approaches its termination. So many speculative theories are involved in glacial geology, that the greatest service can be rendered by, in the first instance, collecting the facts from every quarter, afterwards proceeding to their classification, and finally pointing out the relation of the classified facts to the various theories under discussion. This is the course which it is intended to pursue.

The Committee would respectfully ask Members of the Association who have received schedules to return them with the information desired.

Districts in which boulders are rarest are of especial importance. The evidence respecting the southward extension of the ice-sheet over England, or the reach of the waters of the glacial sea, depends largely upon the facts connected with their presence or absence; while the method of distribution of boulders over England and Wales will furnish the key for the solution of many problems.

The necessity for the work of the Committee is increased by the fact that all over England and Wales the destruction of boulders is rapidly proceeding. Fields are being cleared for agricultural purposes, while the boulders of many districts furnish building-material out of which houses and bridges as well as walls are constructed. It is not too much to say that, in the course of a few years, some of the most curious and important facts connected with the character and distribution of boulders (facts involving the explanation of many of the phenomena of the glacial epoch) will remain simply matters of record without any possible verification in the field. The importance of a careful and thorough carrying out of the work of this Committee will be evident, however long and tedious it may prove to be.

Northumberland.

The following is reported by Mr. Topley:—

(A) Isolated Boulders.

Answers.

1. Parish of Rochbury, Northumberland. It is marked on the 6-inch map of Northumberland (sheet 44) as "Main Stone," about $3\frac{1}{2}$ miles west south-west of the parish church.

2. Length 14 yards, breadth 5 yards, height 4 yards.

N.B. It *rests* on surface of rock.

3. Nearly rectangular.

4. Longer axis S.S.E. and N.N.W.

5. No markings except natural lines of weathering.

6. Composed of sandstone. Similar sandstone forms the mass of the hill on which it rests.

7. Called the "Main Stone."

8. Height above the sea about 1350 feet.

9. Marked on 6-inch map of Northumberland (sheet 44). A township boundary-mark.

11. Not connected with any long ridges of gravel or sand.

Yorkshire.

Mr. E. G. Spencer reports a remarkable isolated boulder.

Answers.

1. The isolated boulder lies in the division of Icornshaw in the township of Cowling, Sutton, in the parishes of Kildwick and Keighley. See Ordnance Map (185) Yorkshire.
2. At least 20 yards round and some 8 yards high above ground.
3. Angular, but one or two rounded corners.
4. The boulder nearly square, but very irregular. Its longest axis from east to west.
5. There are some marks, but more like what would appear from washings. The markings are in the softer parts of the stone.
6. Composed of Millstone-grit, and no rock similar excepting *Hanging Stone Quarry.* This stone is within 2 inches of south left-hand corner of Ordnance Map (sheet 185). Hanging Stone Quarry is 4 to 5 inches north, so will be near a mile off.
7. Popularly known as *Hitching Stone* on Hitching Stone Hill.
8. About 1175 feet above the sea.
11. Perfectly isolated; but within some few hundred yards there are others, but of much smaller dimensions.
12. On heath, and the bottom of stone may be imbedded.

Lancashire.

Two large boulders are reported by Mr. Latham, which he describes as "apparently granite," in the lane called Birkdale Cop, Scambrick, Lancashire. One is much larger than the other, and is $2\frac{3}{4}\times 7\frac{1}{4}\times 7$ yards, and lies about $2\frac{1}{2}$ miles in a direct line from the coast of the Irish sea, and is only $\frac{3}{8}$ of a mile from the Moss, which lies between the sandstones on the coast and the clay land. The other is in a brick-yard at Snape, $\frac{3}{8}$ of a mile more inland, and was found in the clay.

Midland District.

In the *Midland district* the plan suggested by the Geological Section of the Birmingham Natural-History Society, and described in the last Report, is being actively carried out. The minuteness of detail attempted will necessarily render the mapping of the district a work of considerable time. When completed, a map will exist in which the approximate number of boulders and the character of the rocks of which they are formed will be shown, as well as the effect of the configuration of the country on their distribution.

It is necessary to record the general position of the boulders in order to understand their geological meaning.

In the Midland district, around Birmingham as a centre, the general position of the boulders may be described in the following way:—The softness of the Bunter Sandstone of the district has prevented the preservation of glacial striæ to any extent; but in one part (California near Harborne) they have been observed upon the native rock. The striated rock is covered by a thick clay containing boulders in the sense in which they occur in the oldest Boulder-clay of Scotland, many being striated.

Upon this old Boulder-clay, covering a glaciated surface, occurs gravel followed by a thick clay with many boulders scattered through it, striated specimens being less common and less clearly marked.

This is succeeded by sands and gravels, in which boulders of any size are far less frequent and evidently worn. Over the surface of the ground many boulders are spread, any sand and gravel which may at any time have surrounded them having been washed away. These boulders have possibly been dropped by floating ice over the Midland glacial sea. These facts have been

mentioned to show that boulders exist over this district deposited at several ages.

(1) Boulders of the earliest ice period.

(2) Boulders of the period of submergence, in the lower parts of the glacial clays.

(3) Boulders of the period of the reelevation of the land.

These varieties have yet to be traced to their various sources; and upon this work members of the Committee are engaged. It is as impossible to assign all boulders to one epoch of distribution as it is to assign all glacial sands, clays, and gravels to one period.

Leicestershire.

Mr. J. Plant reports both remarkable isolated boulders and groups of boulders, and records one remarkable fact of especial importance. Below the drift-clay, and quite distinct from the surface-boulders freely scattered over the county, a group of boulders has been exposed in an excavation made in the centre of Leicester, 25 feet deep, composed of rocks which Mr. Plant failed to recognize as British. This group, it is suggested, was deposited by a stranded iceberg. The fact of the existence of groups of boulders belonging to the earliest part of the glacial epoch and of foreign origin, points to the submergence of the Midland district in very early glacial times, and is worthy of detailed investigation.

Mr. Plant states that he looked over hundreds of the blocks as they lay piled up on both sides of the roadway, and could not recognize one tenth as "Forest Rocks." Many were dark hornblendic-looking masses, neither dolerite or diorite, but fibrous or slaty rather than granular.

All these patches of boulders (and, in the instance reported, Mr. Plant registered five hundred blocks) are below the drift-clay, and quite distinct from the surface-boulders that lie all over the country, either on the surface or 1 to 3 feet below.

(A) Isolated Boulders.

Answers.

1. (1) In the "Johnstone Close," one mile from Leicester, and near Leicester Abbey. (2) Parish of Humberstone, Leicestershire, on Kirby's Farm.

2. (1) In 1806 stood 7 feet above ground, now about 2 feet; depth in the ground unknown; oval shape. (2) About same height.

3. (1) Has been shaped roughly. (2) Rounded.

4. (1) Upright on short end. (2) Cannot say.

5. No striations seen on either.

6. (1) May be Millstone-grit or may be Upper Keuper Sandstone; no rock near like it. (2) Syenite or granite from Mount Sorel or Buddon, Charnwood Forest, distance 6 miles N.W.

7. (1) Known as the Little John's Stone or St. John's Stone. (2) Known as Hell-Stone. Both have legends connected with them, and one has a festival.

8. (1) About 250 to 300 feet above the sea. (2) Ditto.

11. (1) Has gravel-beds near. (2) Drift-clay.

12. Bottom not seen.

(B) Groups of Boulders.

Answers.

1. All Leicestershire. Potter's Hill in Melton, Leicester; forest near Desford, Hoby, Ratliffe.

2. One near Leicester, Victoria Road, at 12 feet deep; 7 feet × 6 feet, 2 feet exposed; was not dug out. None under 1 cubic foot.

3. All angular or subangular.

5. Striations, sometimes only one side, in other cases two sides, and often at right angles; rarely seen on the granite or syenite, but on greenstone and slate. Erratics of black basalt, not Leicestershire, occur at Hoby, towards Melton.

6. Localities where rocks undoubtedly of the same nature as the boulders occur—Mount Sorel, Buddon Wood, Bradgate Park, Grooby, and Markfield. 5 to 10 or 12 miles from the supposed source, Charnwood Forest, E., S.E., S., S.W., W. One large group at Long Whatton, near Regworth, is due N.

7. Boulders composed of syenite, granite, greenstone, basalt, chert, mountain-limestone, lias limestone, sandstone, but principally igneous rocks.

8. 160 to 300 and 400 feet above the sea. Never saw any boulders on the marlstone, which in this county is 600 to 700 feet.

10. Boulders occur on the surface, but generally seen in excavations of 1 or 2 feet; many have been uncovered in lowering the top of a hill or widening or straightening the road.

Note.—Great numbers of boulders existed over all this county four years ago 6 to 7 feet long, 3 to 5 feet high, particularly in the Leicester forest district, near Desford. They have been gradually broken up by gunpowder. A large water-colour representation of the Little John's Stone, made at the beginning of the century, makes it 7 feet high. It is now much reduced. In a recent uncovering of the granite of Mount Sorel a deposit of drift with boulders and pebbles has been removed, about 8 feet in depth; and the rock below shows clearly that it was subject to the action of waves. It is rounded and worn precisely as rocks upon modern shores.

Warwickshire.

In this district a great change occurs. The drift-beds are reduced almost to beds of pebbles; and local geologists give the name of boulders to specimens which in other parts would not be regarded as worthy of the name. Striations are faint and rare; the grouping, however, is remarkable. They come from all parts of the compass (some possibly from Scandinavia); and metamorphic and volcanic rocks are numerous. Quartzose pebbles with Lower Silurian fossils are abundant; and it is a question of much interest to trace their origin.

The Rev. P. B. Brodie makes the following report of groups of boulders:—

Answers.

1. Groups of boulders at Rowington, Hatton, Lapworth, Hazeler, Packwood, Knowle, Preston, Wroxall, Temple Balsall, Eddsone, Brown's Wood near Watton Wawen, Baddesley.

2. In Hatton and along line in gravel between Hatton Station and Wilmcote many large angular flints occur, and a few flints and some hard chalk are scattered over fields, and in drift generally. One rounded boulder (Rowington) measured $1\frac{1}{2}$ ft. × 2 ft., and 1 ft. in depth, the average size of large boulders. I have seen some still larger. Boulders are of all sizes (frequently as large as a man's head) and are numerous. The still larger boulders are not so frequent. One large block of granite. Other larger ones occasionally occur, but I have not measured them. Scattered about here and there.

3. Both rounded and angular.

5. Have observed a few groovings and striations, but very faint and not numerous; and on small pebbles in district referred to.

6. (*a*) Rocks of the same nature occur at Cumberland and Salop, Malvern.

(*b*) I believe they are derived from all points of the compass, some possibly from Scandinavia, &c. Metamorphic and volcanic rocks are numerous. The most abundant are the quartzites and siliceous pebbles (Budleigh-Salterton pebbles) with fossils (*Orthis redux*, *Lingulæ*, &c.). Carboniferous sandstones and mountain-limestones occur. Not much Lias, and a few pieces of oolite (Great Oolite and Cornbrash) with characteristic fossils. In one small field in Rowington numerous oolitic rock-fragments with chalk and flint and older rocks occur. Felstone (Cumberland or North Wales) recognized; volcanic rock (The Wrekin, Salop) recognized; peculiar amygdaloid granite (Malvern ?).

7. Primitive limestone, porphyritic greenstone, trap, volcanic grit, several varieties of granite, syenite, hard siliceous grit (abundant), pebbles of quartz, jasper agate (numerous), crystalline and schistose slate, sandstone pebbles, felstone, dolerite (varieties of).

Chalk (hard and soft, the former predominates), Cornbrash, forest-marble, Great Oolite, Lias, Magnesian limestone, Mountain-limestone, chert (Carboniferous), Millstone-grit, Permian wood, *Calymene* in nodule (?), Lower-Silurian fossiliferous pebbles. All the above are fossiliferous.

See, on the drift in Warwickshire, Proceedings Geological Society and W. N. Field-Club, 1866, by Rev. P. B. Brodie. Later 'Proceedings' will also give an account of drift near Coventry by Messrs. Whitler. A list and full account of drift in both, Geol. Proc., 1857.

8. The height of the group above the sea is about 400 feet or more. Cannot state this positively.

9. In reply to No 1, many miles.

10. Sometimes exposed on surface in fields, and in the gravel (drift) pits in district.

It must be remarked that the stones called "boulders" in this communication are not of the same size and character as the glaciated boulders scattered over Staffordshire and other neighbouring districts. Attention is called to the quartzose pebbles with certain Lower-Silurian fossils which predominate in the drift of this district. *Orthis redux*, so common in Devon and Normandy, is the most frequent fossil in these pebbles, although fossils are few and far between. The question raised is whether they really have drifted, or whether an old Lower-Silurian centre once extended in this direction.

Devon.

Mr. Widger reports travelled boulders at Bishop's Steignton parish, Lindridge Estate, Coombe Farm near Teignmouth, Devon, from 6 inches to 4 feet in diameter, 300 feet above the sea.

That very great interest attaches to boulders in Devonshire, appears from Mr. Pengelly's remarkable description of the granite boulder on the shore of Barnstaple Bay, North Devon, given in last year's Report. It is hoped that Mr. Pengelly will favour the Committee by carrying on his investigations and contributing them to next year's Report.

Llanrwst.

Mr. Norris reports as follows:—

1. Boulder at Llanrwst, Gorphwysfa, co. Denbigh, one mile N.E. of town next to Cae Brachina.

2. (1) Conical stone, height 7 feet 6 inches, greatest circumference 10 feet, tapers to a point. (2) Height 5 feet, circumference 9 feet.

3. (1) Angular siliceous conglomerate, rough fracture on two sides at right

angles, weathered in spurious conchoidal forms. (2) Fine-grained white felspathic stone with somewhat slaty fissure; rolled on two thirds of its surface, weathered and fissured on the other.

4. Moved.

Note.—Gorphwysfa is 336 feet above the sea-level on the western slope of a hill 500 to 600 feet high towards the vale of Conway. The *soil* of the hill and neighbourhood is *Boulder-clay* on the Denbyshire grit and imperfect slates. All the old walls and hedge-footings have boulders built into them; and the foundations of my own modern house include a large number, some from Pen-y-bryn. At Çae-Mellor Farm near ten tons were removed from two acres in rounded masses reaching a diameter of 3 feet of varica.

6. Conglomerates. On the mountain-top opposite this, between Llanrwst and Bettwys-Coed, I came across a boulder of red porphyry.

8. Height above the sea 336 feet.

Sixth Report of the Committee on the Treatment and Utilization of Sewage, consisting of RICHARD B. GRANTHAM, *C.E., F.G.S.* (Chairman), F. J. BRAMWELL, *C.E., F.R.S.*, Professor W. H. CORFIELD, *M.A., M.D.* (Oxon.), J. H. GILBERT, *Ph.D., F.R.S., F.C.S.*, W. HOPE, *V.C.*, and Professor A. W. WILLIAMSON, *Ph.D., F.R.S., F.C.S.*

DURING the past year the Committee has been able to continue its observations on the amounts of the various crops obtained at Breton's Farm, near Romford, but has not been able, from want of funds, to continue the regular gaugings of the sewage and effluent water, nor to have any more analyses performed; so that neither the quantities of sewage and effluent water nor their composition can be given for the past year.

It has been thought desirable to keep the corresponding Tables numbered as they have been heretofore; and as Tables I., II., and III. cannot be given this year, Table IV. is the first, and shows, as it did last year, the kind of crops grown on the different beds of the farm, the dates when sown or planted, and when cut or gathered, the total produce, and the produce per acre, with other particulars, but does not show this year the approximate amounts of sewage applied, nor the number of dressings which each crop received.

Table V. is a summary of Table IV., the acreage of each plot being given, the kinds of crops grown, and the total amount and amount per acre for each plot; it only corresponds to a small part of Table V. of last year. From it we see that 2353·43 tons of crops were taken off the farm from March 25th, 1873, to March 24th, 1874, this being at the rate of 21·7 tons per acre. In 1872–73 only 1704 tons were taken off, as against 2714 tons during 1871–72; and this was, as explained in last year's Report, due partly to the fact that a much larger amount of crop was standing on March 24th, 1873, than on the same day in 1872, and partly to the fact that cereals were much more largely grown in 1872–73 than in 1871–72.

In Table VII. these particulars are given for the past year; and a comparison is also made with the two previous ones; from which it appears that the area actually fallow on March 24th, 1874, was nearly the same as that on March 24th, 1873, and very much less than that lying fallow on March 24th, 1872; from which it might at first seem that the amount of standing crop left on March 24th, 1874, was about the same as that found on the land on March 25th, 1873, when the year began as far as the records are concerned; but it must be observed that the land sown with spring wheat

is counted as land in crop, so that a fairer comparison of the crops actually standing is got by subtracting the acreage of the land so sown from the total number of acres "in crop" each year; thus:—

	March 24th, 1872.	March 24th, 1873.	March 24th, 1874.
In crop	40·49	87·62	89·09
Acreage of spring wheat recently sown	0·00	22·54	38·13
Do. of crop standing	40·49	65·08	50·96

Thus we see that the amount of crop actually standing was less at the end of 1873–74 than at the end of 1872–73—that is to say, that more of the crop standing at the end of 1872–73 was gathered and reckoned to the credit of the year ending March 24th, 1874, than is left from that year to be gathered during the twelve months ending March 24th, 1875.

It should be noticed that as the total of crops for 1872–73 was smaller partly on account of the greater amount of cereals grown (26·18 acres), the total for 1873–74 would be larger than it is but for the still greater amount (38·82 acres) of cereals grown.

Table VI. corresponds with part of Table VI. of last year's Report; it is, like Table V., compiled from the particulars in Table IV., the results being exhibited according to crops instead of according to plots or beds; the total acreage of each description of crop is given, the total amount of each crop and the amount per acre, and the estimated amount of nitrogen for each crop, these estimates being obtained from the same data which were used in preceding years.

The total amount of nitrogen estimated to be recovered is 22,766 lbs., as against 15,704 lbs. in 1872–73: the amount that year was no doubt exceptionally small, on account of the large amount of crop still ungathered at the end of the year. The total amount of nitrogen brought to the farm from the town was shown in last year's Report to be practically the same in 1872–73 as the year before, and may be considered to be approximately 27 tons, or 60,480 lbs.

Assuming the same amount for the year 1873–74, there would be 37·6 per cent. of the nitrogen applied recovered in the crops. In 1871–72 the amount recovered was estimated at 41·76 per cent., and in 1872–73 at 26 per cent. The amount of nitrogen lost in the effluent water this year has not been ascertained.

To take the total of the three years during which the quantities of nitrogen have been determined or estimated, it appears that about 168,000 lbs. of nitrogen have been distributed on the farm, of which it is estimated nearly 58,200 lbs. have been recovered in the crops, or 34·6 per cent.; of the remainder, some has escaped in the effluent water (chiefly in the form of nitrates and nitrites) and been lost, and some, as shown in last year's Report, has been stored in the soil.

In conclusion your Committee feels very strongly the desirability of continuing these observations (if they are to be made really useful) through a series of years, as only thus can a reliable average be obtained, and considers it a matter of much regret that, for the reason already given, the analyses of the sewage and effluent water had to be discontinued.

TABLE IV.—*Breton's*

Statement showing Crops grown from

Plot.	No. of beds (inclusive).	Acreage.	Crop.	Date when sown or planted.
A	1 to 29	9·8	Cabbage	Oct. 1872
"	"	9·8	Barley	June 1873
"	"	9·8	Italian rye-grass	" "
Total A	....	9·8	....	....
B	8 to 16	4·20	Cabbage	Sept. 1872
"	1 " 5	2·43	Oats	March 1873
"	6 " 7	·96	Wheat	" "
"	17 " 26	4·54	"	" "
"	1 " 3	1·47	Sprouting broccoli	Aug. "
"	4 " 5	·97	Brussels sprouts	" "
"	6 " 8	1·43	Cabbage	" "
"	8	·44	Peas	May "
"	9 to 14	2·80	Cabbage-plants	Aug. "
"	15 " 16	·92	Turnips	" "
"	17 " 26	4·54	Cabbage	Oct. "
"	11 " 16	2·78	Peas	March 1874
"	1 " 10	4·80	Fallow.	
Total B	....	12·12	....	....
C	All.	1·97	Wheat	March 1873
"	"	1·97	Cabbage	Oct. "
Total C	....	1·97	....	....
D	All.	6·93	Italian rye-grass	Aug. 1872
E	1 to 22	5·76	Cabbage	Oct. 1872
"	1 " 16	4·35	"	June and July 1873
"	17	·24	Cauliflowers	June 1873
"	18	·24	Sprouting broccoli	" "
"	part 19	·12	Onions	" "
"	" 19	·12	Lettuce	" "
"	" 19	·12	Cabbage-plants	Aug. "
"	20 to 22	·69	Mangold	May and June 1873
"	1 " 22	5·76	Wheat	March 1874
Total E	....	5·76	....	....

Sewage-Farm.

March 25, 1873, to March 24, 1874.

Date when cut or gathered.	Produce.		Remarks.
	Total.	Per acre.	
	tons.	tons.	
April to June 1873 ...	124·74	12·7	
Oct. 1873	13·52	1·4	Including 6·94 tons straw.
Dec. 1873 and Jan. 1874	32·63	3·3	Sown the day after the barley; once cut.
....	170·89	17·4	The whole plot under crop at the end of the year. (Italian rye-grass.)
May to July 1873......	92·92	22·1	One third consumed by cattle, waste, &c.
Aug. 1873	6·58	2·7	4·33 tons straw.
" " .... " "	15·44	2·8	9·54 tons straw.
March 1874	5·52	3·8	One third ploughed in or consumed by cattle.
" "	0·75	0·8	
" "	2·11	1·5	One half ploughed in or consumed by cattle.
Aug. and Sept. 1873...	1·27	2·9	1 ton straw.
Sept. and Nov. " ...	11·67	4·2	Plants replanted on farm.
Oct. to Dec. " ...	13·30	14·5	
....	......	......	Crop remained March 1874.
....	......	......	" " "
....	149·56	12·3	Part of plot under crop at end of year.
Aug. 1873	5·24	2·7	3·47 tons straw.
....	......	......	Crop remained March 1874.
....	5·24	2·7	Plot all under crop (Cabbage) at the end of year.
July to Dec. 1873......	452·95	65·4	Grass ploughed in. Plot fallow, March 25, 1874; Mangold sown afterwards.
May and June 1873 ...	85·42	14·8	One fourth ploughed in or carted to cattle.
Sept. to Nov. " ...	73·07	16·8	" " " "
Oct. 1873	1·25	5·2	
Jan. and Feb. 1874 ...	2·58	10·7	One half leaves, &c., consumed by cattle or ploughed in.
Oct. and Nov. 1873 ...	2·25	18·7	
July 1873	1·50	12·5	
Oct. "	2·43	20·2	
Nov. "	12·25	17·9	
....	......	......	Crop remained March 1874.
....	180·75	31·4	Plot all under crop of Spring Wheat at end of year.

TABLE IV.

Plot.	No. of beds (inclusive).	Acreage.	Crop.	Date when sown or planted.
F	12 to 18	1·48	Strawberries	March to Nov. 1872
„	1 „ 6	1·27	Oats	April 1873
„	7 „ 11	1·06	Barley	„ „
„	15 „ 18	·85	Cabbage	Sept. „
„	1 „ 14	2·97	Wheat	Feb. 1874
Total F	....	3·82	....	....
G	5 to 10 & 17 „ 22	2·82	Cabbage	Sept. and Oct. 1872
„	1 „ 4	·94	Carrots	March 1873
„	11 „ 12	·47	Onions	Sept. 1872
„	11	·23	Hardy green plants	May 1873
„	13 & 15 to 16	·70	Spinach	„ „
„	1 to 8 & 11 & 12	2·35	Mangold	July „
„	13 to 16	·94	Turnips	„ „
„	9 „ 10 & 17 „ 20	1·41	Sprouting broccoli	„ „
„	21	·23	Spinach	„ „
„	½ 22	·12	Lettuce	May „
„	½ 22	·12	Cabbage	„ „
„	½ 22	·12	Hardy greens	July „
„	1 to 8 & 11 to 12	2·35	Cabbage	Nov. „
„	13 to 16, 9 & 10, & 17 to 22	2·82	Fallow.	
Total G	....	5·17	....	....
H	1 to 17½	4·11	Onions	Feb. and March 1873
„	17½ „ 24	2·29	„	„ „ „
„	17½ „ 19	·76	Hardy green plants	May 1873
„	17½ „ 19	·76	Cabbage	July „
„	20 „ 24	1·53	French beans	May „
„	1 „ 5	1·08	Hardy greens	Aug. „
„	6 & 7	·47	Spinach	„ „
„	8 to 24	4·86	Cabbage	Oct. and Nov. 1873
„	1 „ 5	1·08	Fallow.	
Total H	....	6·40	....	....
I	1 to 3½	1·30	Onions	April 1873
„	3½ „ 6	·94	Carrots	„ „
„	7 „ 12	2·29	Savoys	June „
„	13 „ 16	1·56	Carrots	April „
„	17 „ 18	·58	Cabbage	June „
„	1 „ 16	6·09	Wheat	Feb. 1874
„	17 „ 18	·58	Cabbage	Nov. 1873
Total I	....	6·67	....	....

(*continued*).

Date when cut or gathered.	Produce.		Remarks.
	Total.	Per acre.	
	tons.	tons.	
June to July 1873 ...	0·09	0·06	
Aug. 1873	4·69	3·7	2·89 tons straw.
" "	2·71	2·5	1·73 " "
Mar. "	1·20	1·4	Seed bed.
....	......	......	Crop remained March 1874.
....	8·69	2·3	Part of plot under crop at end of year.
May to July 1873 ...	51·87	18·4	One third carted to cattle or ploughed in.
June and July " ...	4·28	4·6	
June 1873	0·61	1·3	The produce of one bed only; the other failed.
July "	7·07	30·7	
May to July 1873......	8·02	11·4	One tenth only sent to market; remainder given to cattle or ploughed in.
Nov. 1873	44·10	18·8	One sixth tops &c.
Sept. to Dec. 1873 ...	26·60	28·3	
March 1874	8·74	6·2	
Aug. 1873	2·25	9·8	
July "	1·12	9·3	
Aug. "	2·65	22·1	
Nov. "	2·00	16·7	
....	......	......	Crop remains.
....	159·31	30·8	Part under crop at end of year.
July to Sept. 1873 ...	36·12	8·8	
....	......	......	Crop failed.
July 1873	4·28	5·6	
Oct. and Nov. 1873 ...	12·37	16·3	
July to Sept. " ...	2·52	1·7	
Dec. 1873	8·29	7·7	
Oct. 1873 to Mar. 1874	0·67	1·4	This crop still remains.
....	......	......	" "
....	64·25	10·0	Part under crop at end of year.
Sept. and Oct. 1873 ...	8·43	6·5	
Aug. 1873	4·69	5·0	
Dec. 1873 to Feb. 1874	26·30	11·5	One fifth to cattle or ploughed in.
Aug. 1873	14·70	9·4	
Aug. to Oct. 1873 ...	10·87	18·7	
....	......	......	Crop remains.
....	......	......	" "
....	64·99	9·7	Plot all under crop at end of year.

TABLE IV.

Plot.	No. of beds (inclusive).	Acreage.	Crop.	Date when sown or planted.
K	All.	4·44	Italian rye-grass	Sept. 1872 ....
L	Part.	1·22	Mangold	July 1873 ....
,,	,,	·66	Hardy greens	,, ,, ...
,,	,,	1·00	Savoys	,, ,, ...
Total L	....	2·88	....	....
M	All.	3·17	Italian rye-grass	Sept. 1872 ....
N	1 to 16	4·15	Italian rye-grass	March and May 1872..
,,	,,	4·15	Barley	June 1873 ....
,,	,,	4·15	Italian rye-grass	,, ,, ...
Total N	....	4·15	....	....
O	All.	5·92	Cabbage	Sept. 1872 ....
,,	1 to 8 & 10 to 17	5·55	Hardy greens	July 1873 ....
,,	9	·37	Cabbage-plants	,, ,, ...
,,	9	·37	Hardy greens	Oct. ,, ...
,,	1 to 17	5·92	Onions	March 1874 ....
Total O	....	5·92	....	....
P	All.	3·50	Wheat	March 1873 ....
,,	,,	3·50	Hardy greens	Aug. ,, ...
,,	,,	3·50	Wheat	Feb. 1874 ....
Total P	....	3·50	....	....
Q	1 to 10	1·04	Cabbage	Oct. 1872 ....
,,	1 ,, 20	2·34	Mangold	May 1873 ....
,,	1 ,, 20	2·34	Wheat	Feb. 1874 ....
Total Q	....	2·34	....	....
R	Part.	2·40	Mangold	April 1873 ....
,,	,,	2·40	Wheat	Feb. 1874 ....
,,	,,	·12	Oziers	Jan. 1873 ....
Total R	....	2·52	....	....
S	All.	·22	Rhubarb	Feb. 1873 ....

(*continued*).

Date when cut or gathered.	Produce.		Remarks.
	Total.	Per acre.	
	tons.	tons.	
Mar. 1873 to Jan. 1874	277·06	62·4	Crop remains; cut eight times in year.
Nov. 1873	25·05	20·5	
Dec. „	3·23	4·9	
Feb. 1874	4·38	4·4	
....	32·66	11·4	Plot all fallow at end of year.
Mar. 1873 to Jan. 1874	182·49	57·5	Crop remains; cut eight times in year.
March to May 1873 ...	140·96	34·0	Grass ploughed in May 1873.
Sept. 1873	4·74	1·1	Including straw 3·47 tons.
Nov. 1873 to Mar. 1874	26·74	6·4	This grass was set with the barley and still remains.
....	172·44	41·5	Plot all under crop at end of year.
April to June 1873 ...	85·89	14·5	
Oct. to Dec. „ ...	69·86	12·6	
Aug. and Sept. „ ...	2·33	6·3	Transplanted.
Jan. 1874	·71	1·9	
....	......	......	Crop remains.
....	158·79	26·8	Plot all under crop at end of year.
Aug. 1873	8·68	2·5	6·07 tons straw.
Jan. and Feb. 1874 ...	10·82	3·1	
....	......	......	Crop remains.
....	19·50	5·6	Plot all under crop at end of year.
April 1873..............	2·00	1·9	
Nov. „	38·00	16·2	
....	......	......	Crop remains.
....	40·00	18·1	Plot all under crop at end of year.
Oct. and Nov. 1873 ...	45·32	18·8	
....	......	......	Crop remains.
Cleared Nov. 1873 ...	·50	4·1	Oziers used for bunching greens, &c.
....	45·82	18·2	Plot nearly all under crop at end of year.
Feb. and March 1874	0·17	·8	Crop remains.

TABLE IV

Plot.	No. of beds (inclusive).	Acreage.	Crop.	Date when sown or planted.
U	All.	2·53	Wheat	March 1873 ....
"	"	2·53	Hardy greens	Aug. " ....
"	"	2·53	Wheat	Feb. 1874 ....
Total U	....	2·53	....	....
V	Part.	2·93	Cabbage	Oct. 1872 ....
"	"	3·00	Scarlet beans...............	May 1873 ....
"	All.	5·93	Wheat	March 1874 ....
Total V	....	5·93	....	....
W	All.	2·75	Wheat	March 1873 ....
"	"	2·75	Hardy greens	Sept. and Oct. 1873 ...
"	"	2·75	Wheat	March 1874 ....
Total W	....	2·75	....	....
X	All.	3·86	Wheat	March 1873 ....
"	"	3·86	"	" 1874 ....
Total X	....	3·86	....	....
Y	....	5·60	Hay	Permanent grass ......
"	....	5·60	Grass-meadow	" " ......

N.B. The boundaries of plots Q and V

(*continued*).

Date when cut or gathered.	Produce. Total.	Per acre.	Remarks.
	tons.	tons.	
Aug. 1873	7·05	2·8	4·62 tons straw.
Jan. and Feb. 1874 ...	5·62	2·2	
....	......	......	Crop remains.
....	12·67	5·0	Plot all under crop at end of year.
May to July 1873......	58·48	20·0	
Aug. and Sept. "	0·50	·2	This crop was nearly all destroyed by an accident with the sewage.
....	......	......	Crop remains.
....	58·98	9·9	Plot all under Spring Wheat at end of year.
Aug. 1873	6·61	2·4	Straw 4·62 tons.
Feb. to Mar. 1874......	5·12	1·9	
....	......	......	Crop remains.
....	11·73	4·3	Plot all under Spring Wheat at end of year.
Sept. 1873	8·99	2·3	Straw 6·36 tons.
....	......	......	Crop remains.
....	8·99	2·3	Plot all under Spring Wheat at end of year.
July 1873	15·50	2·8	
July to Nov. 1873......	60·00	10·7	One cutting only. Plot used for grazing from July to November 1873. Quantity grazed computed.

ave been rearranged since last year.

TABLE V.—*Breton's Sewage-Farm.*

Season 1873–74.—Summary of Cropping Return.

Plot.	Acreage.	Crops.	Produce.	
			Total.	Per acre.
			tons.	tons.
A	9·80	Cabbage, barley, and Italian rye-grass ...	170·89	17·4
B	12·12	Cabbage, oats, wheat, sprouting broccoli, Brussels sprouts, peas, cabbage-plants, and turnips.	149·56	12·3
C	1·97	Wheat	5·24	2·7
D	6·93	Italian rye-grass	452·95	65·4
E	5·76	Cabbage, cauliflowers, sprouting broccoli, onions, lettuce, cabbage-plants, and mangold.	180·75	31·4
F	3·82	Strawberries, oats, barley, and cabbage ...	8·69	2·3
G	5·17	Cabbage, carrots, onions, hardy green plants, spinach, mangold, turnips, sprouting broccoli, lettuce, and hardy greens.	159·31	30·8
H	6·40	Onions, hardy green plants, French beans, cabbage, hardy greens, and spinach.	64·25	10·0
I	6·67	Onions, carrots, savoys, and cabbage	64·99	9·7
K	4·44	Italian rye-grass	277·06	62·4
L	2·88	Mangold, hardy greens, and savoys	32·66	11·4
M	3·17	Italian rye-grass	182·49	57·5
N	4·15	Italian rye-grass and barley	172·44	41·5
O	5·92	Cabbage, hardy greens, and cabbage-plants	158·79	26·8
P	3·50	Wheat and hardy greens	19·50	5·6
Q	2·34	Cabbage and mangold	40·00	18·1
R	2·52	Mangold and oziers	45·82	18·2
S	·22	Rhubarb	·17	·8
U	2·53	Wheat and hardy greens	12·67	5·0
V	5·93	Cabbage and scarlet beans	58·98	9·9
W	2·75	Wheat and hardy greens	11·73	4·3
X	3·86	Wheat	8·99	2·3
Y	5·60	Hay and meadow-grass	75·50	13·5
	108·45		2353·43	21·7

TABLE VI.—*Breton's Sewage-Farm.*

Summary of Crops gathered from March 25th, 1873, to March 24th, 1874, showing the quantity of each kind of Produce and Nitrogen contained therein.

Crop.	Total acreage of each description of crop.	Produce of each crop.		Nitrogen estimated in crops.		
		Total.	Per acre.	Per cent.	Total.	Per acre.
		tons.	tons.		lbs.	lbs.
Italian rye-grass	28·49	1112·83	39·1	0·54	13,461	472
Grass (meadow)	5·60	60·00	10·7	0·54	726	130
Hay		15·50	2·8	2·00	694	124
Oziers	0·12	0·50	4·1			
Cabbage	43·85	620·02	14·1	0·25	3,472	79
Hardy greens	17·55	117·00	6·7	0·25	655	37
Savoys	3·29	30·68	9·3	0·25	172	52
Brussels sprouts	0·97	6·75	0·8	0·25	4	4·1
Broccoli	3·12	16·84	5·4	0·25	94	30
Cauliflowers	0·24	1·25	5·2	0·25	7	29
Beans (French and runner)	4·53	*3·02	*0·7	0·375	25	5·5
Spinach	1·40	10·94	7·8	0·25	61	44
Peas	0·44	peas ·27 straw 1·00	·6 2·3	3·40 0·80	62	141
Carrots	3·44	23·67	6·9	0·20	106	31
Turnips	1·86	39·90	21·5	0·18	161	87
Lettuce	0·24	2·62	10·9	0·25	15	63
Mangold	9·00	164·72	18·3	0·25	922	102
Onions	6·00	47·41	7·9	0·22	234	39
Oats	3·70	grain 4·05 straw 7·22	1·1 1·9	2·0 0·6	278	75
Barley	15·01	grain 8·83 straw 12·14	0·6 0·8	1·6 0·5	452	30
Wheat	20·11	grain 17·33 straw 34·68	0·8 1·7	1·8 0·6	1,165	58
Strawberries	1·48	0·09	0·06	0·1		
Rhubarb	0·22	0·17	0·8			
	170·66	2353·43	13·8	......	22,766	133·4

* Crop nearly all destroyed by accident.

TABLE VII.—*Breton's Sewage-Farm.*

Statement of Land in crop and Land lying fallow on March 24th, 1874.

Plot.	Acreage.	Area in crop.	Area fallow.
		acres.	acres.
A	9·80	9·80	......
B	12·12	7·32	4·80
C	1·97	1·97	......
D	6·93	......	6·93
E	5·76	5·76	......
F	3·82	2·97	·85
G	5·17	2·35	2·82
H	6·40	5·32	1·08
I	6·67	6·67	......
K	4·44	4·44	......
L	2·87	......	2·87
M	3·17	3·17	......
N	4·15	4·15	......
O	5·92	5·92	......
P	3·50	3·50	......
Q	2·34	2·34	......
R	2·52	2·52	......
S	·22	·22	......
U	2·53	2·53	......
V	5·93	5·93	......
W	2·75	2·75	......
X	3·86	3·86	......
Y	5·60	5·60	......
	108·44	89·09	19·35

Comparison.

	In crop.	Fallow.	Total.
	acres.	acres.	acres.
March 24, 1872 ...	40·49	63·39	103·88
,, ,, 1873 ...	87·62*	19·93	107·55
,, ,, 1874 ...	89·09*	19·35	108·44

* In regard to this comparison, it should be stated that the area described as "in crop" comprises land sown with spring wheat.

On March 24th, 1873, about 22½ acres,
,, ,, ,, 1874 ,, 38 ,,

There was no wheat in on March 24th, 1872. The spring wheat being sown in March, these figures should be borne in mind in comparing the above.

SECTION I.—*Fourth Note on the Dry Earth System.*

Dr. Gilbert has supplemented the results given in former Reports by the determination of the nitrogen (by the soda-lime process) in soil which has now passed through a Moule's earth-closet five times. The determinations were made upon the air-dried manure; but, for uniformity and for fairer comparison, the percentage is, in each case, calculated upon the soil as dried at 100° C. The results of the series are as follows:—

	Before used.	After using once.	After using twice.	After using three times.	After using four times.	After using five times.
Percentage of nitrogen in soil dried at 100° C.	0·073	0·240	0·383	0·446	0·540	0·614

Dr. Russell has also determined the quantity of nitrogen existing as nitrates in the soil in its present state—that is, after it had passed through the closet five times; and he finds it to amount to 0·20 per cent. in the soil as fully dried. Supposing the whole of this to be in addition to that determined by the soda-lime method, the total nitrogen in the dried soil would be raised to 0·814 per cent.—still, therefore, to considerably less than 1 per cent. in the fully dried condition, and scarcely $\frac{3}{4}$ per cent. in the air-dried condition. The Committee must again say "That such a manure, even if disposed of free of charge, would bear carriage to a very short distance only." It may be observed, however, that the process of emptying was still unaccompanied by any offensive smell, and that the soil after drying on the floor of a shed could scarcely be distinguished from ordinary mould.

The *increase* in the percentage of nitrogen (determinable by the soda-lime method) in the soil, calculated as fully dried, by each use was as follows:—

	After using once.	After using twice.	After using three times.	After using four times.	After using five times.
Increase in the percentage of nitrogen in soil dried at 100° C.	0·1670	0·1427	0·0626	0·0949	0·0785

The gain of nitrogen as ammonia or organic nitrogen was therefore considerably greater by the first and second than by either of the subsequent uses of the soil. The differences observed may probably be partly due to the differences in the length of time during which the manure was exposed to dry, and in the temperature of the periods—circumstances which would affect the degree of further change, and, as one result of this, the amount of nitrogen passing into the form of nitrates. The general result is, however, an average gain of total nitrogen of scarcely 0·15 per cent. by each passage through the closet. On this point it may be remarked that, if only two pounds of soil were used per head per day, and as much as one third of the total nitrogen voided in fæces and in urine by an average individual in 24 hours were collected with it in the closet, the nitrogen so added to the soil would amount to about 0·5 per cent. of its weight by each use, or by using five times to nearly 2·5 per cent. Probably in practice a larger

amount of soil, and a smaller proportion of the total nitrogen daily voided, would be collected in an earth-closet. The increased percentage of nitrogen actually found is seen to be less than one third of the amount calculated on the foregoing assumption. There can, indeed, be little doubt that there is a considerable evolution of nitrogen in some form; and the probability is that it takes place to a great extent as free nitrogen.

The Committee would refer to their former Reports (III. pp. 187 & 188, IV. p. 143, V. pp. 413 & 439) for their opinion of the system in its other aspects than that of the composition and manurial value of the product.

Report on the Anthropological Notes and Queries for the use of Travellers published by the Committee, consisting of Colonel Lane Fox, Dr. Beddoe, Mr. Franks, Mr. Francis Galton, Mr. E. W. Brabrook, Sir John Lubbock, Sir Walter Elliot, Mr. Clements Markham, and Mr. E. B. Tylor. By Colonel A. Lane Fox, *Secretary of the Committee.*

These Notes and Queries are the result of a resolution of the General Committee passed at the Brighton Meeting in 1872, to the following effect:—"That Colonel A. Lane Fox, Dr. Beddoe, Mr. Franks, Mr. Francis Galton, Mr. E. W. Brabrook, Sir John Lubbock, Sir Walter Elliot, Mr. Clements Markham, and Mr. E. B. Tylor be a committee for the purpose of preparing and publishing brief forms of instruction for travellers, ethnologists, and other anthropological observers; that Colonel Lane Fox be the Secretary, and that the sum of £25 be placed at their disposal for the purpose."

At the Bradford Meeting in 1873 the Committee was reappointed, and the grant increased to £50, with the view of covering all possible expenses and producing a work calculated to suffice for the use of travellers for some time to come.

A report on the progress of the work was made to the General Committee last year, to which it is unnecessary to refer here. The object of the book is to promote accurate anthropological observation on the part of travellers, and to enable those who are not anthropologists themselves to supply the information which is wanted for the scientific study of anthropology at home.

Similar instructions on a smaller scale have been published by this Association in former years, as also by the Smithsonian Institute, the Anthropological Society of Paris, the Anthropological Institute of Great Britain and Ireland, and other bodies; but many of them have become obsolete, and are but little known to travellers at the present time.

The chief defect of most of these works has been their insufficient detail. It is not enough to publish such general queries as might suggest themselves unaided to any well-informed traveller; what is wanted is to draw attention to minutiæ which might ordinarily be expected to pass unnoticed, but which are often of the first importance to the student of the different branches of anthropological research.

To this end it has been thought advisable that the questions on the several sections should be drawn up by different anthropologists, each of whom has paid special attention to the subject treated.

The work has been divided into two main divisions—the first relating to the constitution of man, physical and mental; the second to the history and development of culture.

Under the first division we have questions relating to ethnology proper,

and directed to the acquirement of knowledge respecting the geographical distribution, migration, and intermixture of the different races of mankind, as well as the physical and mental capacity of these races for civilization.

Under the second division we have questions bearing upon the rise and progress of the arts, religions, laws, customs, and institutions of mankind, and the means by which they have been developed and spread by war, commerce, and other causes, and including all that comes under the head of the new science of Sociology, to which comparatively little attention has been paid hitherto.

The whole of the first or ethnological division of the subject has been intrusted to Dr. Beddoe, with the exception of the section on physiognomy, which has been contributed by Mr. Darwin, and some remarks on heredity by Mr. Galton. In Section I. is given a description of the various instruments to be employed in measuring the different parts of the body and skulls. A description of the parts to be measured is given in Section II., which includes two diagrams showing the positions in which the measurements are to be taken. Under anatomy and physiology are included questions relating to the internal organism and the soft parts of the body—muscles, circulation, respiration, temperature, nerves, tissues, &c. In Section IV., under development and decay, are given inquiries into the periods of growth, length of life, puberty, dentition, death-rate, birth-rate, &c. Section V. is devoted to the qualities, mode of growth, and texture of the hair. Under Section VI. are given instructions for estimating accurately the colour of the eyes, skin, and hair of races. "Even educated men," says Dr. Beddoe, "differ very widely as to the appreciation of colours and their nomenclature. Such a term as olive, for example, is used by different observers to denote hues totally different from each other. Moreover, decided colours, such as bright red or yellow, or coal-black, are apt to attract the eye, and their frequency is likely to be overestimated. It is therefore most desirable that information as to the colour of the skin, hair, and eyes should be collected in a systematic manner, by comparing those of every individual observer with a table of numbered squares showing the various shades of colour graduated from coal-black to the fairest European flesh-colour, and including all the different hues that are to be found amongst the races of mankind." In order that the data of European and foreign observers might tally as closely as possible in their system of appreciating these colours, we have adopted the chromatic tables of M. Broca, who has kindly given his assistance in obtaining the identical shades which he has employed. These tables occupy three pages of the book.

Passing over two sections relating to the odour and motions of the body, we come to Section IX. on physiognomy, by Darwin, which includes such remarks as the following:—"General remarks on expression," he says, "are of comparatively little value; and memory is so deceptive that it ought not to be trusted. A definite description of the countenance under any emotion or frame of mind, with a statement of the circumstances under which it occurred, would possess much value. 1. Is astonishment expressed by the eyes and mouth being opened wide, and by the eyebrows being raised? Are the open hands often raised high up, with the fingers widely separated, and the palms directed towards the person causing astonishment? Is the open mouth in some cases covered by the hand? or is the hand carried to some part of the head? 2. Does shame excite a blush when the colour of the skin allows it to be visible? and especially how low down the body does the blush extend? 3. When a man is indignant or defiant, does he frown, hold his body and head erect, square his shoulders, and clench his fists? 4. When considering

deeply on any subject, or trying to understand any puzzle, does he frown or wrinkle the skin beneath the lower eyelids? 5. When in low spirits, are the corners of the mouth depressed, and the inner corner of the eyebrows raised by that muscle which the French call the 'Grief muscle'?" The questions on this head are sixteen in number.

After a section on "Pathology" we come to "Abnormalities," which are natural deformities, and are distinct from Deformations or artificial deformities, which have a distinct section allotted to them under the division of "Culture."

Under the section devoted to the "Senses" are given various tests to serve as means of comparison, including two pages of the test-dots used for testing the eyesight of recruits in the British army. By this means a comparison of the eyesight of natives with that of Europeans can be made. The instructions for judging distances in use by the army are also given for the same object.

Under the head of "Crosses" are given tables for indicating the racial position of mongrels and mestizos, and for estimating the number of return crosses which restore apparent purity of blood.

Under "Psychology" special attention is drawn by a series of questions to the desirability of distinguishing between the effect of European customs when introduced amongst savages and exposed to contact with native surroundings; and, on the other hand, to the effect of culture upon natives of the same race who have been removed at an early age from native surroundings and brought up in European schools.

All the foregoing sections are included under the head of "Constitution of Man," and, as already said, are ethnological in their bearings; but with the adoption of the term anthropology our science has widened its sphere. It is true that in the old days ethnology did practically include a broader range of subjects than are comprehended under the strict derivation of the term "ethnos." It is equally true that anthropology has and does at the present time confine itself far too exclusively to questions of race. But as the widening of our science has been coincident with the change of name it may be well to consider for a moment the causes that may be expected to assign to race-questions a less important place in our deliberations than formerly.

According to the old dogma, all human life was destroyed by the universal deluge with the exception of one family; and as the whole of the existing races of mankind must have descended from one or other of the three sons of Noah, the ethnological or racial question was of paramount and immediate importance, and was limited to the determination of the period, and the causes by which such races as the Fuegians, the Tasmanians, Australians, or Esquimaux were constrained to change their colour and other physical peculiarities, and descend to the comparatively low condition in which they are now found.

Since, however, science has demonstrated the error of this theory, and has shown that long prior to the supposed era of the deluge the whole world was peopled by races of beings some of which were, in all probability, human only in form, and since the researches of Mr. Darwin and others have shown the great probability of the descent of the human species from the lower forms of life, the racial question, though still of primary importance, zoologically considered, has been transferred to the domain of palæontology, to be determined perhaps by geologists in the far distant future. And as a line must be drawn somewhere, man's origin, in the proper acceptation of the term—man as a progressive being—has become indissolubly connected with the origin and development of culture. It is to this science of culture or sociology that Sir John Lubbock, Mr. Tylor, Mr. Herbert Spencer, and others have of late years turned their attention.

It has been shown that the rise of culture in man has been one of evolution, corresponding in all respects with the evolution of those species of animals amongst which that of man is included, that every art, custom, and institution has a history of development which is capable of being studied apart from that of the development of the particular races amongst whom those customs thrive, and that the attention of anthropologists in the future will in a great measure be occupied in tracing the sequence of that development and the laws by which it is governed.

This is the science of "Sociology," the rise of which has been marked by the conversion of ethnology into anthropology, or the study of man in all its bearings, and for the prosecution of which far greater accuracy of detail is required in the description of the social institution of savages and barbarous races than has been devoted to the subject hitherto. Every work of man's hand and brain has now to be studied in its bearings upon social evolution; just as in the study of natural history every part of an organism and every variety of species has to be studied in its bearings upon the evolution of species. The social anatomy of every tribe and race has to be considered in all its parts, and the questions by which the attention of travellers have been directed to the several subjects have therefore been classified, as far as possible, by their affinities, and by their relation to the general results.

Under the head of "History" it has been endeavoured to collect all the information that can be obtained from the traditions of the people, and from inquiries as to their mode of recording events. Archæology is divided into Palæolithic period, Cave period, Neolithic or Surface period, Megalithic monuments, Tumuli, &c.; engravings of the principal types of implements to be looked for have been contributed by Mr. John Evans, and the attention of travellers has been directed, by means of a diagram, to the position in which such implements are likely to be found. When it is considered that it is only within the last fifteen or twenty years that archæologists have begun to study in earnest the prehistoric monuments and implements of civilized countries, and that the antiquities of savage and uncultivated countries are entirely unknown, important results may be expected from this branch of inquiry.

The important subjects of food, narcotics, cannibalism, personal ornament, tattooing, and clothing have been treated by Mr. Franks. War, hunting, games, archæology, stone implements, circumcision, drawing, and ornamentation, by myself. Deformations, by Professor Busk. Machinery, string, weaving, dyeing, basketwork, and engineering, by Mr. John Evans. Medicine, by Dr. Barnard Davis. Trade, money, weights, and measures, domestication of animals, by Mr. Hyde Clarke. Communications, causes that limit population, population, and statistics, by Mr. Galton. Contact of savages with civilized races, by Sir T. Gore Browne. Marital relations, relationships, treatment of widows, infanticide, and memorial structures, by Sir John Lubbock. Pastoral and monastic life, by Mr. Howorth. Government, laws, and crimes, by Mr. Brabrook. Etymology, arithmetic, morals, covenants, religions, superstitions, magic, customs, taboo, language, poetry, writing, by Mr. Tylor. Music, by Mr. Carl Engel. The subject of religion is treated by Mr. Tylor in great detail, and is divided under numerous subheadings.

The work concludes with a valuable section by Mr. Galton, on the mode of obtaining statistics and striking averages. Many of the questions throughout the book are of a nature which, from the apparent insignificance of the subjects referred to, might appear to those ignorant of the requirements of anthropology unimportant or even childish; and yet from that very cause

these apparently trivial matters, owing to their having been less influenced by progressive changes, are often of the utmost value in tracing the connexions between the culture of different races and localities.

The necessity which exists for laying the groundwork of our science on a sounder basis must have struck most of those who have attended the meetings of this department during past years. Why is it that our leading biologists devote their attention so exclusively to the lower forms of life? It cannot be because men of science think the noblest study for mankind is beast kind, but because beast kind is more scientifically treated than mankind, especially as regards the branch of descriptive anthropology, upon which all sound deductions must be based.

Travellers have usually recorded only those customs of modern savages which they have chanced to observe; and, as a rule, they have observed chiefly those which their experience of civilized institutions has led them to look for. Nor are there wanting instances in which the information thus obtained has been lamentably distorted in order to render it in harmony with preconceived ideas.

In attempting to trace the distribution of cognate arts and customs, the anthropologist is perpetually thwarted by the difficulty of distinguishing between positive and negative evidence, *i. e.* between non-existence and non-recorded existence; so that, to use the words of Mr. E. B. Tylor, it is "playing against the bank for a student to set up a claim to isolation for any art or custom, not knowing what evidence there may be against him buried in the ground or hidden in remote tribes."

The rapid extermination of savages at the present time, and the rapidity with which they are being reduced to the standard of European manners, renders it of urgent importance to correct these sources of error as soon as possible.

It is hoped that the questions contained in this work may be a means of enabling the traveller to collect information without prejudice from his individual views.

To this end it is particularly to be hoped that they will endeavour to answer the questions as fully as possible, not confining themselves to a detailed account of those things which exist, but also, by special inquiries directed to the subject, endeavouring to determine the non-existence of others to which attention is drawn*.

On Cyclone and Rainfall Periodicities in connexion with the Sun-spot Periodicity. By Charles Meldrum†.

The catalogue of cyclones experienced in the Indian Ocean from 1847 to 1873, submitted last year, indicates that during that period the number of cyclones in the space between the equator and 34° S. lat., and the meridians of 40° E. and 110° E., was much greater in the years of maximum than in the years of minimum sun-spot frequency.

It will now, and in subsequent Reports, be shown that not only the num-

* The Notes and Queries have been published by Stanford, of Charing Cross, and a notice has been inserted in the flyleaf requesting that any communications from travellers relating to the queries contained in the volume may be sent to the Secretary of the Anthropological Institute of Great Britain and Ireland, 4 St. Martin's Place, Trafalgar Square, London. The names of Mr. John Evans and Mr. F. W. Rudler have been added to the Committee.

† A grant of £100 was made at Bradford to Prof. Balfour Stewart, Mr. J. Glaisher and Mr. J. N. Lockyer, to assist Mr. Meldrum in conducting meteorological researches in Mauritius.

ber of cyclones, but their duration, extent, and energy were also much greater in the former than in the latter years, and that there is a strong probability that this cyclonic fluctuation has been coincident with a similar fluctuation of the rainfall over the globe generally.

The present communication is confined to the twelve years 1856–67, comprising a complete sun-spot cycle.

With regard to the cyclones of the Indian Ocean, the investigation is based upon the extensive collection of observations made by the Meteorological Society of Mauritius, on the assumption that the observations are so numerous that no cyclone of any considerable extent or violence can have escaped detection.

A chart has been prepared for noon on each day of the period during which a cyclone lasted. The chart shows the positions of the vessels, the direction and force of the wind, the state of the weather and sea, &c. In this way the position of the centre of the cyclone is ascertained for each day. Then, by examining the several charts, the duration, extent, &c. of the cyclone are determined.

The number of cyclones thus examined for the twelve years is one hundred and thirteen, and their tracks have been laid down on six charts.

The results of the investigation are given in Table I. Column 1 shows the dates; 2, the number of cyclone on chart; 3, the distance traversed; 4, the mean radius of cyclone; 5, area of cyclone, or πr^2; 6, the duration in days; and 7, total cyclonic area, or $D\pi r^2$.

From Table I. we obtain the following general results:—

Years.	Number of cyclones.	Total distance traversed.	Sum of radii.	Sum of areas.	Duration, in days.	Sum of total areas.	Relative areas.	Wolf's rotation sun-spot numbers.
		miles.	miles.	sq. miles.				
1856.	6	850	815	356,468·5	20	1,221,931·0	1·00	4·2
1857.	5	1850	740	354,820·0	19	1,270,130·0	1·04	21·6
1858.	12	3880	1656	775,215·8	39	2,890,781·7	2·37	50·9
1859.	14	5640	2026	1,107,440·4	48	4,809,189·9	3·94	96·4
1860.	13	8054	3131	2,620,929·9	61	13,616,789·7	11·14	98·6
1861.	12	8730	2861	2,349,552·1	72	14,937,699·7	12·23	77·4
1862.	14	6140	2968	2,406,879·1	57	11,370,279·7	9·53	59·4
1863.	9	6320	2137	1,590,155·7	49	7,550,447·3	6·18	44·4
1864.	7	4920	1341	876,628·5	36	4,893,009·5	4·00	46·9
1865.	8	3970	1426	904,150·4	28	3,396,409·1	2·78	30·5
1866.	8	3130	960	509,961·2	44	2,762,221·2	2·26	16·3
1867.	6	2280	881	414,985·5	27	1,913,845·5	1·57	7·3

The total cyclonic area in 1860 and 1861 was about twelve times greater than in 1856 and 1857, and nearly eight times greater than in 1867.

In short, all the factors were greatest in the years of maximum sun-spot frequency.

It will be noticed that the cyclonic area increased rapidly from 1858 to 1860, and diminished slowly from 1861 to 1866.

The registers for the years 1856, 1857, 1866, and 1867 have been examined with special care in order that nothing might be omitted; and to give the utmost possible weight to those years, every instance of even an ordinary gale has been taken into account.

In 1856 there was no great hurricane at all; and the same may be said of 1857, 1866, and 1867.

From the chart for 1866 it will be seen that in April of that year there was a number of small cyclones. The S.E. trade and N.W. monsoon were in collision for a considerable time, and several cyclonic eddies of short duration were formed.

If we could obtain good values of the mass of air in motion and the velocity of the wind, it would probably be found that the ratios of cyclonic energy were still greater than those of cyclonic area; for the cyclones were much more violent in the years of maximum than in those of minimum sun-spot frequency.

Assuming the mass to be nearly proportional to the area, and the velocity of the wind in a strong gale to be fifty-five miles, in a whole gale seventy miles, and in a hurricane eighty-five miles an hour, the amount of cyclonic energy in 1860 was about eighteen times greater than in 1856, the squares of the velocities being nearly three to five.

Although the results are necessarily rough approximations, yet the fact that the number and violence of the cyclones of years of maximum sun-spot were far greater than in the years of minimum sun-spot is beyond all doubt. There is independent evidence of this, which any one may examine for himself. When a great hurricane takes place in the Indian Ocean the disabled ships are obliged to put into the nearest port; and the newspapers, in their "Shipping Intelligence," announce the arrivals of the vessels, the dates and localities of the bad weather, and the amount of damage sustained.

For upwards of twenty years the 'Commercial Gazette' of Port Louis has published all arrivals of vessels and all maritime events which have been reported by them. Considering, then, the geographical position of Mauritius, a cyclone periodicity, if one exists, should be traceable in the "Shipping Intelligence." Now, from Table II., which gives the published reports for 1856, 1860, and 1867, it will be seen that the number of storms and the damage sustained in 1856 and 1867 were insignificant compared with the long list of hurricanes and disasters in 1860.

Table III. gives as complete a list of hurricanes and storms experienced in Mauritius as I have hitherto been enabled to prepare. The list comprises only such storms as, from the violence of the wind, committed considerable damage. Taking each maximum and minimum sun-spot year, and two years on each side of it, we get the following results:—

Max. Years.	Number of Hurricanes.
1695	1
1759	1
1760	1
1761	1
1771	1
1772	1
1786	1
1788	1
1806	1
1815	1
1817	1
1818	1
1819	2
1828	1
1829	1
1836	1
1848	1
Total	18

Min. Years.	Number of Hurricanes.
1723	1
1731	1
1743	1
1754	1
1766	1
1786	1
1800	1
1824	1
Total	8

Table IV., which contains a list of Bourbon (Réunion) hurricanes and gales from 1733 to 1754, gives the following results:—

Max. Years.	Number of Hurricanes.
1736	2
1737	2
1738	1
1739	2
1740	3
1748	2
1750	3
1751	1
1752	2
Total	18

Min. Years.	Number of Hurricanes.
1733	2
1743	1
1744	1
1745	1
1746	3
1747	1
1754	2
Total	11

For the two islands the number of cyclones in the maxima years was thirty-six, and for the minima years nineteen. This result is favourable.

It would appear also from Mr. Poey's researches, and from investigations made at Mauritius in 1872, that the cyclones of the West Indies are, upon the whole, subject to the same periodicity.

The rainfall for the twelve years under discussion is given in Tables V. to IX.

Taking the mean annual rainfall at thirty stations in Scotland, thirty-one stations on the continent of Europe, and the annual falls at Greenwich, Calcutta, Bombay, Mauritius, and the Cape, we get:—

Years.	Scotland, 30 stations.	Greenwich.	Continent of Europe, 31 stations.	Calcutta.	Bombay.	Mauritius.	Cape of G. Hope.	Sums.
1856.	37·6	21·9	24·8	64·2	65·9	46·2	21·9	282·5
1857.	36·0	21·4	21·2	69·0	51·3	43·4	22·7	265·0
1858.	37·4	17·8	22·6	59·8	62·4	35·5	24·1	259·6
1859.	40·8	25·9	25·7	68·7	77·2	56·9	36·7	331·9
1860.	39·9	32·0	27·5	52·6	62·1	45·1	29·1	288·3
1861.	45·3	20·4	23·7	89·1	76·9	68·7	25·4	349·5
1862.	46·6	26·5	26·3	73·4	73·6	28·4	32·0	306·8
1863.	42·6	19·8	24·6	61·1	77·7	33·4	25·6	284·8
1864.	40·0	16·9	23·9	84·2	45·6	24·1	18·9	253·6
1865.	35·7	28·7	23·4	61·6	77·8	44·7	18·7	290·5
1866.	44·7	30·7	26·8	65·7	78·4	20·6	19·2	286·1
1867.	41·5	28·4	29·1	76·7	62·3	36·0	23·0	297·0

It appears from the rainfall at sixty-seven stations that the maximum fall was in the years 1859 to 1862, and the minimum in the years 1857, 1858, and 1864. We thus find a certain degree of correspondence between the cyclone and rainfall fluctuations; and it is possible that if we had returns from America, the correspondence would be much greater; for it would appear from researches by Mr. G. M. Dawson that the level of the American great lakes was considerably less in 1866–68 than in 1859–61*.

A large number of additional rainfall returns has been received from Europe and other parts of the world; and the results, which will be communicated in another Report, afford fresh evidence of a Rainfall Periodicity.

* The year 1867 has been almost the only exception to the rule, in Europe, since the commencement of the century; and as most of the stations are in that part of the world, the results for 1856–67 are not so favourable as for previous cycles.

TABLE I.—Showing the duration, extent, &c. of Cyclones experienced in the Indian Ocean from 1856 to 1867.

Date.	Number of Cyclone.	Distance traversed.	Mean Radius.	Area, πr^2.	Duration.	Total Cyclonic Area, $D\pi r^2$.	Remarks.
		miles.	miles.	square miles.	days.	square miles.	
1856.							
February 1 to 6	I.	550	165	85486·5	6	512919·0	On the 13th October the Belgian barque 'Fanny' is said to have experienced a hurricane in 15° S. and 83° E. But this has not been confirmed.
March 20 ,, 22	II.	Stationary?	100	31400·0	3	94200·0	
31	III.	,,	150	70650·0	1	70650·0	
April 4 ,, 5	IV.	300	130	53066·0	2	106132·0	
November 7 ,, 11	V.	Stationary?	120	45216·0	5	226080·0	
12 ,, 14	VI.	,,	150	70650·0	3	211950·0	
Total	6	850	815	356468·5	20	1221931·0	
1857.							
January 28 to 31	I.	500	180	101736·0	4	406944·0	Schooner 'Romp' is said to have encountered a gale on 19th February. No confirmation.
February 13 ,, 15	II.	300	150	70650·0	3	211950·0	
March 23 ,, 24	III.	Stationary?	150	70650·0	2	141300·0	
December 4 ,, 7	IV.	480	160	80384·0	4	321536·0	
26 ,, 31	V.	570	100	31400·0	6	188400·0	
Total	5	1850	740	354820·0	19	1270130·0	

1858.							
January 12 to 20	I.	1110	172	92893·8	9	836044·2	
February 24 „ 28	II.	650	186	108631·4	5	543157·0	
March 6	III.	Stationary?	90	25434·0	1	25434·0	
6 „ 10		690	148	68778·6	5	343893·0	
18	IV.	Stationary?	85	22686·5	1	22686·5	
31 „ April 2	V.	540	180	101736·0	3	305208·0	
April 2 „ 4	VI.	200	195	119398·5	3	358195·5	
18 „ 22	VII.	Stationary?	90	25434·0	5	127170·0	
November 1 „ 4	VIII.	390	120	45216·0	3	135648·0	
11	IX.	Stationary?	145	66018·5	1	66018·5	
December 15 „ 16	X.	300	95	28338·5	2	56677·0	
16		Stationary?	150	70650·0	1	70650·0	
Total	12	3880	1656	775215·8	39	2890781·7	
1859.							
January 1 to 2	I.	Stationary?	120	45216·0	2	90432·0	
24 „ 28	II.	720	130	53066·0	5	265330·0	
February 16 „ 20	III.	340	158	78387·0	5	391935·0	
March 7 „ 12	IV.	1280	268	225527·4	6	1353164·4	
17 „ 21	V.	1200	290	264074·0	5	1320370·0	
April 5	VI.	Stationary?	105	34618·5	1	34618·5	
5 „ 6	VII.	„	50	7850·0	2	15700·0	
17 „ 20	VIII.	570	195	119398·5	4	477594·0	
21 „ 22	IX.	Stationary?	150	70650·0	2	141300·0	
22	X.	„	70	15386·0	1	15386·0	
June 3 „ 5	XI.	420	135	57226·5	3	171679·5	
November 16 „ 19	XII.	Stationary?	90	25434·0	4	101736·0	
December 1 „ 5	XIII.	930	125	49062·5	5	245312·5	
9 „ 11	XIV.	180	140	61544·0	3	184632·0	
Total	14	5640	2026	1107440·4	48	4809189·9	

TABLE I. (*continued*).

Date.	Number of Cyclone.	Distance traversed.	Mean Radius.	Area, πr^2.	Duration.	Total Cyclonic Area, $D\pi r^2$.	Remarks.
		miles.	miles.	square miles.	days.	square miles.	
1860.							
January 10 to 16	I.	1444	362	411478·2	7	2880347·4	
18 „ 21	II.	540	202	128124·6	4	512498·4	
25 „ 28	III.	530	128	51445·8	4	205783·2	
February 11 „ 16	IV.	780	240	180864·0	6	1085184·0	
22 „ 27	V.	430	188	110980·2	6	665881·2	
22 „ 25	VI.	370	130	53066·0	4	212264·0	
28 „ 29	VII.	250	200	125600·0	2	251200·0	
March 2 „ 6	VIII.	1050	290	264074·0	5	1320370·0	
18 „ 26	IX.	1120	265	220506·5	9	1984558·5	It is reported that the American ship 'John Hareen' experienced a hurricane on the 14th November in 10° S. and 104° E.
April 26 „ 27	X.	210	167	87571·5	2	175143·0	
May 27 „ 31	XI.	930	380	453416·0	5	2267080·0	
29 „ 30	XII.	Stationary?	255	204178·5	2	408357·0	
December 4 „ 8	XIII.	400	324	329624·6	5	1648123·0	
Total	13	8054	3131	2620929·9	61	13616789·7	
1861.							
January 18 to 20	I.	320	360	406944·0	3	1229832·0	
29 „ Feb. 3 ...	II.	1080	110	237994·0	6	227964·0	
February 5 „ 16	III.	910	274	235738·6	12	2828863·2	Two tracks from 5th to 16th.
11 „ 20	IV.	950	300	282600·0	10	2826000·0	
28 „ March 6 ..	V.	1600	330	341946·0	7	2393622·0	
March 12 „ 15	VI.	480	290	264074·0	4	1056296·0	
28	VII.	Stationary?	150	70650·0	1	70650·0	
April 4 „ 7	VIII.	360	210	138474·0	4	553896·0	
12 „ 18	IX.	980	245	188478·5	7	1319349·5	
November 4 „ 6	X.	600	150	70650·0	3	211950·0	
December 18 „ 26	XI.	850	192	115753·0	9	1041777·0	
26 „ 31	XII.	600	250	196250·0	6	1177500·0	There were two cyclones.
Total	12	8730	2861	2349552·1	72	14937699·7	

1862.							
January 2 to 8	I.	780	227	161801·1	7	1132607·7	
9 ,, 11	II.	570	280	246176·0	3	738528·0	
16 ,, 19	III.	270	240	180864·0	4	723456·0	
23 ,, 25	IV.	330	108	36625·0	3	109875·0	
28 ,, 29	V.	Stationary?	80	20096·0	2	40192·0	
February 21 ,, 22	VI.	390	210	138474·0	2	276948·0	
23 ,, March 1...	VII.	970	450	635850·0	7	4450950·0	
March 1 ,, 3	VIII.	240	100	31400·0	3	94200·0	
6 ,, 12	IX.	Stationary?	100	31400·0	6	188400·0	Gales in three different places.
10 ,, 12		300	330	341946·0	3	1025838·0	
23 ,, 27	X.	650	220	151976·0	5	759880·0	
October 10 ,, 12	XI.	160	200	125600·0	3	376800·0	
November 30 ,, Dec. 3 ...	XII.	890	150	70650·0	4	282500·0	
December 18 ,, 22	XIII.	590	273	234021·0	5	1170105·0	
Total	14	6140	2968	2406879·1	57	11370279·7	
1863.							
January 10 to 15	I.	910	150	70650·0	6	423900·0	
31 ,, Feb. 6 ...	II.	1270	240	180864·0	7	1266048·0	
February 9 ,, 12	III.	350	312	305660·2	4	1222640·8	
18 ,, 24	IV.	1680	240	180864·0	7	1266048·0	
March 12 ,, 14	V.	Stationary?	120	45216·0	3	135648·0	Gales in three places.
April 19 ,, 23	VI.	500	265	220506·5	5	1102532·5	
May 12 ,, 19	VII.	860	225	158962·5	8	1271700·0	
November 20	VIII.	Stationary?	300	282600·0	1	282600·0	
25 ,, 28		360	195	119398·5	4	477594·0	
December 6 ,, 9	IX.	390	90	25434·0	4	101736·0	
Total	10	6320	2137	1590155·7	49	7550447·3	

TABLE I. (*continued*).

Date.		Number of Cyclone.	Distance traversed.	Mean Radius.	Area, πr^2.	Duration.	Total Cyclonic Area, $D\pi r^2$.	Remarks.
	1864.		miles.	miles.	square miles.	days.	square miles.	
January	10 to 18	I.	1390	220	151976·0	8	1215808·0	
	18	II.	Stationary?	180	101736·0	1	101736·0	
	29	III.	Stationary?	108	36625·0	1	36625·0	
February	25 „ 29	IV.	900	300	282600·0	5	1413000·0	
	28 „ March 6...	V.	1470	188	110980·2	7	776861·4	
April	13 „ 19	VI.	620	142	63315·0	7	443205·0	
	22 „ 28	VII.	540	203	129396·3	7	905774·1	
	Total	7	4920	1341	876628·5	36	4893009·5	
	1865.							
January	10 to 12	I.	400	215	145146·5	3	435439·5	
	21 „ 22	II.	140	120	45216·0	2	90432·0	
February	12 „ 13	III.	Stationary?	180	101736·0	2	203472·0	
	21 „ 23		640	190	113354·0	3	340062·0	
	19 „ 24	IV.	1320	230	166106·0	6	996636·0	
March	23 „ 26	V.	480	200	125600·0	4	502400·0	
April	14 „ 17	VI.	690	200	125600·0	4	502400·0	
December	8 „ 11	VII.	300	161	81391·9	4	325567·6	
	Total	8	3970	1496	904150·4	28	3396409·1	

1866.							
January 6 to 12	I.	630	290	264074·0	7	1848518·0	Several small cyclones.
February 2 „ 4	II.	660	130	53066·0	3	159198·0	
March 3 „ 8	III.	420	100	31400·0	6	188400·0	
30 „ 31	IV.	100	100	31400·0	2	62800·0	
April 6 „ 17	V.	510	52	8490·6	12	101887·2	
13 „ 22	VI.	460	52	8490·6	10	84906·0	
November 12 „ 14	VII.	350	180	101736·0	3	305208·0	
30	VIII.	Stationary ?	60	11304·0	1	11304·0	
Total	8	3130	960	509961·2	44	2762221·2	
1867.							
January 15 to 19	I.	660	181	102869·5	5	514347·5	
February 1 „ 2	II.	240	150	70650·0	2	141300·0	
14 „ 20	III.	600	150	70650·0	7	494550·0	
April 11 „ 14	IV.	Stationary ?	120	45216·0	4	180864·0	
May 24 „ 28	V.	540	160	80384·0	5	401920·0	
December 15 „ 18	VI.	240	120	45216·0	4	180864·0	
Total	6	2280	881	414985·5	27	1913845·5	

TABLE II.—Reports of bad weather experienced in the Indian Ocean from the Equator to 32° S. in the years 1856, 1860, and 1867. (Extracted from the 'Commercial Gazette' of Port Louis, Mauritius.)

Date.	Reports.	Remarks.
1856.		
No date ...	French ship 'Auguste,' from Muscat, experienced strong N.W. winds; sprung a leak. Brig 'Alert,' from Table Bay, experienced heavy gales ever since ship left the Cape; carried away sails and masts.	The reports of the 'Auguste' and 'Alert,' which appear in the 'Commercial Gazette' of the 11th of February, probably refer to the gale of Feb. 1–6, the track of which is registered in Table I.*
Feb. 4	Brig 'Ituna,' in 32° S. and 58° E.P., experienced a heavy gale from N.W. to S. and W.; carried away cross-jack yard.	
„ 4–6 ...	Barque 'Caliphurnia' experienced strong southerly winds; no position given.	
„ 4, 5 ...	French barque 'Parcou de la Barbinais,' in 24° S. and 57° E.P., experienced strong winds from southward and heavy sea.	
April 4	The 'Annie' met with a hurricane not far from the island (Mauritius), and on Friday night (the 4th) it was most violent. The vessel was on her beam ends and in the greatest danger. Lowest barometer 28·40 inches.	The track of the small cyclone experienced by the 'Annie' and 'Estafette' is registered in Table I.
No date	The 'Estafette' that left Réunion for Ceylon on the 29th March, met with a hurricane, and was obliged to put back; dismasted. She is at St. Mary, repairing.	This was the cyclone experienced by the 'Annie.'
Oct. 13	The Belgian barque 'Fanny,' in 14° 56′ S. and 83° 30′ E., experienced a very severe hurricane, ship making much water; carried away three yards and lost several sails.	As the log-book of this vessel was not received, and her report has not been confirmed, the alleged hurricane has not been entered in Table I.
Nov. 7	Ship 'Her Majesty,' in 11° 30′ S. and 82° 20′ E., experienced a strong gale; lost fore topmast, fore yard, and maintop gallant mast.	
„ 11	French ship 'St. Michel," in 5° S. and 89° E.P., experienced a gale from S.E.; sprung a leak.	
Dec. 28	French barque 'Augustine,' at about 150 miles from Mauritius, experienced a gale of wind from N.N.E.; ship sprung a leak; put back for repairs.	No evidence of a cyclone; not entered in Table I.
1860.		
Jan. 15	French barque 'Louise and Gabrielle,' in 26° S. and 61° E.P., experienced a severe hurricane, which lasted twenty-four hours; wind N.E. to N.W.; mainmast carried away, with every thing attached to it; three boats stove in, a suit of sails carried away, every thing on deck swept away; bore up to Mauritius for repairs.	From January the 10th to the 28th there were three hurricanes, the tracks of which are entered in Table I.

* In the *Overland* 'Commercial Gazette' the dates are given; they were the 4th to the 6th of February.

TABLE II. (*continued*).

Date.	Reports.	Remarks.
1860. Jan. 25	Ship 'Atieth Rohaman,' from Port Louis, bound to Bombay, experienced a violent hurricane in 18° S. and 57° E.; wind from E.S.E. to W.; lost topsails, jib, foretop gallant and royal masts, &c.	
„ 26	Barque 'Stag,' in 22° S. and 59° E., experienced hard gales from E.N.E., N.N.E., and N., with heavy sea, much rain, and lightning.	
„ 15	Ship 'Gulnare,' in 30° S. and 70° E., experienced a hurricane which lasted ten hours; barometer 28·40 inches; wind N.E. to N.W., W.S.W. and S.; sprung a leak, and lost spars and sails; bore up to Mauritius for repairs.	
„ 18	Ship 'Cossipore,' in 17° S. and 75° E., at midnight, got into the vortex of a cyclone, blew and cut away a suite of sails, lost main topmast, yards, jib, and flying booms, mizzen topmast, boats, &c.; wind E. to E.S.E. and W. to N. and N.N.E. Barometer just before the calm 28·32 inches.	
„ 10	Schooner 'Yarra,' in 20° S. and 71° E., experienced a very severe hurricane (barometer 28·30 inches, wind E. by S. to S.E.), and all at once fell calm, then recommenced at N.N.E.; lost bulwarks, sails, &c.	
„ 27	French barque 'Gironde,' put to sea from Réunion, experienced a gale from S.E.; then calm; afterwards a gale from N.W.; sprung a leak.	
„ 22	American barque 'Uriel;' violent gale from N.E., with an awful sea; saw a sail astern under close-reefed topsails making signals of distress, the Portuguese brig of war 'Mondego:' at 4.20 P.M. had received fifty-seven men in five boats; at 5.30 the captain, 1st lieutenant, and eight men got on board, leaving forty-three men in the wreck; at 6 the brig heeled to port and went down instantly.	
„ 27	French ship 'Arthur and Mathilde,' in 25° S. and 58° E.P., experienced a cyclone; wind E. by N. to N.W.	
„ 10	Ship 'Anglo-Saxon,' in 17° S. and 63° E., experienced all the symptoms of a cyclone; wind veering from E. to N.W. by the S.	
„ 10	French brig 'Ibis,' in 18° S. and 62° E., experienced a gale which lasted twenty-four hours; wind S.E. to N.W. by the S.	
„ 12–14..	Barque 'Anna Henduron' experienced very strong westerly gales, with high cross sea.	
„ 15	French barque 'Bonne Mère,' in 23° S. and 58° E.P., experienced a gale from S.S.E.	
„ 14–15..	Brig 'Woodlark,' in 25° S. and 59° E., experienced a severe hurricane; wind S.E. to W. by the S.	

TABLE II. (*continued*).

Date.	Reports.	Remarks.
1860. Jan. 10	French ship 'Bailly de Suffren,' in 18° S. and 63° E.P., experienced a cyclone which lasted forty-eight hours; wind E. round to N.	
„ 12, 13..	Ship 'Maria Gray,' in 20° S. and 65° E., experienced a cyclone; wind S.E. to E.N.E. and N.W.	
„ 11	Ship 'Akbar,' in 20° S. and 62° E., experienced a heavy gale which lasted thirty-six hours; wind E. to S.	
„ 15	Barque 'Jane Lakey,' in 24° S. and 65° E., experienced a gale from N.E. to N.N.W., W.S.W., and S.	
„ 15, 16..	Danish ship 'Calloe,' in 26° S. and 63° E., experienced a very heavy gale; wind N. to S.S.W., with very heavy cross sea; sprung a leak; bore away for Mauritius for repairs.	
Feb. 14	Barque 'Good Hope,' in 30° S. and 51° E., experienced a hurricane which lasted fifty hours; wind E.S.E. to N.W.	
„ 22	Schooner 'Phœnix,' from Mauritius, bound to Johanna, in 14° S. and 56° E., experienced a gale from S.E.; barometer 28·60 inches; wind shifted to southward and westward, carried away foremast, jibboom, and main topmast, &c.; bore up to Mauritius for repairs.	In February there were four cyclones (see Table I.).
„ 27	French barque 'Rosalie,' in 18° S. and 69° E.P., experienced very heavy weather, with high cross sea, stove in long boat, started the cookhouse, &c.	
„ 24–27..	Hanoverian schooner 'Johanna,' in 18° S. and 56° E., experienced a hurricane; wind N.E. to N.N.E.; barometer 28·00 inches; lost head of foremast, fore topmast, and top gallant mast, a suit of sails, &c. On the 29th signalled the French ship 'Turgot' (put to sea from Réunion on the 25th), with loss of main and main topsail yard and sails.	
„ 21	French barque 'Chêne,' in 17° S. and 52° E.P., experienced a hurricane which lasted four days; lost mainmast, sails, and damaged rudder, &c.	
„ 26	French schooner 'Messager du Nossibé,' at about 15 miles N.E. of Bourbon, experienced a cyclone; wind S.E. to N.; lost mainmast and every thing attached to it; rigging, boats, and rudder damaged, &c.; bore up for Mauritius for repairs.	
„ 24, 25..	French ship 'Eléonore' sprung mainmast and sustained other damage in the voyage from Tamatave to Réunion.	
Mar. 2	Ship 'Adelaide,' in 10° S. and 80° E., experienced heavy gales, with every appearance of a cyclone passing.	There was a cyclone from the 2nd to the 6th of March (see Table I.).

TABLE II. (*continued*).

Date.	Reports.	Remarks.
1860. Feb. 26	French ship 'Alfred,' from Réunion, lost mainmast and long boat.	
" 24	French ship 'Virginie,' in 4° S. and 89° E., experienced very bad weather, which lasted five days; wind at W.; sprung a leak; put in for repairs.	
" 28	Prussian ship 'Der Süd,' in 12° S. and 102° E., experienced a hurricane; vessel hove on her beam ends; had to cut away the fore mast. The hurricane lasted twelve hours.	
No date	Barque 'Helen Lindsay,' in 18° S. and 62° E., experienced a hurricane which lasted thirty-six hours; ship hove on her beam ends, and sprung a leak. Lost bulwarks, sails, &c.	A hurricane from March the 18th to the 26th (see Table I.).
Mar. 19	Barque 'Teazer,' in 18° S. and 64° E., experienced a heavy hurrciane from N.E., shifting to S.E.; fore and main masts went by the board, &c. Barometer 28·60 inches.	
April 9	Barque 'Bessie Young,' in 24° S. and 65° E., had strong winds from S.E.; a heavy sea struck the vessel aft; bore up for Mauritius.	No evidence of a cyclone; not entered in Table I.
May 6	Ship 'Blue Rock,' in 15° S. and 78° E., experienced heavy gales and heavy sea; ship hove on her beam ends; had to cut away the main mast; bore away for Mauritius for repairs. Spoke the ship 'Entoclydon' from Bombay bound to Liverpool; Captain reported that on the 6th of May he lost his rudder, and his ship was very leaky.	There is not sufficient evidence that this was a cyclone; it is therefore not entered in Table I.
" 29	Barque 'Josephine,' in 18° S. and 59° E., experienced heavy gales from south-eastward; lost jibboom and sails.	
" 30	Barque 'Queen of the Wave,' in 18° S. and 67° E., experienced a cyclone for thirty-six hours; barometer 29·25 inches; sprung main topmast, and lost maintop gallant yard, a portion of the bulwarks, sails, &c. Wind N.N.E. to S.S.E.	Two cyclones in May: one from the 27th to the 31st, and one on the 29th and 30th.
" 30, 31..	Oldenburg barque 'Fanny Kirchner,' in 16° S. and 80° E., experienced very bad weather, sprung a leak, and had to bear away for Mauritius.	
" 28, 29..	Ship 'Shah Allum,' in 11° S. and 77° E., experienced a very heavy gale from S.E. to N.W., which lasted thirty-eight hours; sustained no damage.	
" 30	Ship 'Mary Sparks,' in 14° S. and 79° E., experienced a hurricane from N.N.E. to N.E. and S.E.; had to cut away main and mizzen masts, as the ship was lying on her beam ends; lost boats, bulwarks, sails, &c.	
" 28	Ship 'Hurricane,' in 7° S. and 83° E., experienced a hurricane, lost sails, yards, &c.	

TABLE II. (*continued*).

Date.	Reports.	Remarks.
1860.		
May 24	Prussian barque 'Heros' experienced very heavy weather, lost sails; bore up for Mauritius on 2nd of June.	There is not sufficient evidence of a cyclone.
Oct. 2	Ship 'Adelaide,' in 11° S. and 81° E., experienced a very heavy gale; wind W.S.W. to E.N.E.	
Nov. 16	Hamburg brig 'Canoe,' from Batavia, 7th November, experienced hard gale with heavy sea since leaving the Strait; on the 18th November bore up for Mauritius for repairs.	
„ 14	American ship 'John Haven' experienced a hurricane in 10° S. and 104° E.; wind from N.N.E to N. and N.W.; carried away fore topmast and all attached to it, main top gallant mast, &c.; lost topsails, top gallant sails, &c.; bore up for Mauritius for repairs.	Not having seen this vessel's log, her hurricane has not been entered.
Oct. 10	Barque 'Skimmer of the Waves,' in 14° S. and 91° E., experienced a heavy gale from S.S.E.; sprung a leak; bore away for Mauritius for repairs.	There is not sufficient evidence of a cyclone.
Dec. 6	Barque 'Wave,' from Colombo, bound for London, in 8° S. and 83° E., experienced a hurricane from W.N.W. to N.: ship thrown on her beam ends; carried away mizzen topmast, main topmast, &c. Barometer 28·563 inches.	
„ 5	Ship 'Helvellyn,' in 9° S. and 85° E., experienced a hurricane from S.S.W. to N.W. Sprung a leak; bore up for Mauritius for repairs.	A cyclone from the 4th to the 8th December. See Table I.
„ 9–10 ...	Ship 'Algeria,' in 15° S. and 77° E., experienced a hurricane; wind from N.E. to S.S.E.; lost top gallant masts, flying jibboom, and sails. Barometer fell to 27 inches.	
„ 5	Barque 'Colinda,' in 3° S. and 85° E., experienced a terrific gale from N.W. to S.E., which lasted fifty hours.	
1867.		
Jan. 9–11 ...	Steamer 'Dromedary,' in 30° S. and 56° E., experienced a very heavy gale, with high cross sea; wind from E. to N.W.	
„ 16	'Rio,' in 13° S. and 70° E.P., experienced very heavy weather; wind S.S.W. to N.N.W.; bad weather lasted three days.	The track of a hurricane from the 15th to the 19th January is entered in Table I.
„ 15–19 .	Barque 'Seringapatam,' in 18° S. and 70° E., experienced a very heavy gale from E. to S.E. on the 15th, and on the 18th and 19th a severer gale, blowing a hurricane. Barometer 29·38 inches.	
„ 18	'Agenosia' experienced a complete hurricane from E. to S.E.; barometer 28·80 inches; cut away fore topmast, taking with it jibboom and mizzen top gallant mast &c.	

TABLE II. (*continued*).

Date.	Reports.	Remarks.
1867.		
Feb. 1	Schooner 'Jessie Kelly,' in 20° S. and 80° E., experienced a severe hurricane, which lasted twenty-four hours; wind from eastward, veering round the compass; lost about fifty pieces of timber off the deck.	See Table I. for notice of hurricane from 1st to 2nd February.
„ 1	Ship 'Montrose,' in 15° S. and 79° E., experienced a very heavy hurricane from N.E.; barometer (ranging 29·50 inches) suddenly fell two tenths of an inch; cut away mizzen top gallant mast; gale lasted thirty-six hours, ending W. by N.	
„ 3	Ship 'Briton,' in 20° S. and 59° E., experienced a severe hurricane; barometer ranging 29·75 inches; wind E.N.E. to N. and N.N.W., and shifted to W. and S.W.; bad weather lasted.	
Dec. 17	Barque 'Warrior,' in 27° S. and 59° E., experienced a strong breeze S. by E., with a dull cloudy threatening appearance; barometer falling from 29·90 to 29·70 inches; ended with very rainy weather; no gale.	See Table I. for track of a cyclone from 15th to 18th December.
„ 16	Ship 'Crochranges,' in 25° S. and 60° E., had a gale with threatening appearance; at midnight strong gale and very heavy squalls.	
„ 16	Barque 'Formosa,' in 20° S. and 65° E., experienced a severe gale from N.E. to N.; no damage.	
No date	Ship (Dutch ?) 'Zeemanschep,' in 26° S. and 67° E., experienced a gale which increased to a hurricane, with a tremendous sea. Barometer fell from 30·10 to 28·70 inches.	
Dec. 16–17 .	Ship 'Berar,' in 24° S. and 68° E., experienced a heavy gale, with thunder and lightning; ship hove on her beam ends; cut away top gallant mast; every plate, all clothing, and every book on board washed away. Barometer 29·30 inches.	
„ 5	French barque 'Carmeline' experienced a severe hurricane. No position given.	No evidence of this having been a tropical hurricane.
	N.B. I find no mention in the 'Commercial Gazette' of the cyclones of April and May entered in Table I.	

TABLE III.—List of Hurricanes experienced at Mauritius from 1695 to 1848. Compiled from information contained in the Mauritius Almanacs for 1837 and 1869, and from observations made by M. Ceré, M. Labrette, Colonel Lloyd, &c.

Year.	Day and Month.	Remarks.
1695	9 February	Hurricane.
1723	23 December	Hurricane.
1731	4 February..................	Hurricane. Public archives destroyed.
1743	8–9 March	Hurricane.
1754	?	Hurricane.
1759	?	Hurricane.
1760	18 January	Hurricane. On 1st December meteorological phenomenon.
1761	?	Very violent hurricane. On 11th June, 1762, meteorological phenomenon.
1766	?	Hurricane.
1771	February	Strong. Much damage.
„	March	Velocity of wind 150 feet per second.
1772	1 March	Hurricane.
1773	9 April	Port Louis Church blown down.
1786	June	Strong.
1788 ... } 1789 ... }	31 December to 1 January	Stronger at Bourbon.
1800	February	Strong.
1806	3 „	Hurricane.
1807	28 „	Hurricane.
1813	19 „	Storm.
1814	3 „	Storm.
„	10 April	Storm.
1815	15 February	Hurricane and meteorological phenomena.
1817	13–15 „	Barometer fell to 27 inches 8 lines (French).
1818	28 „ to 1 March ...	Hurricane. Theatre damaged. Barometer 26 2·6 inches.
1819	25 January	Hurricane. Barometer 27 inches (Fr.).
„	28 March	Hurricane. „ 27 inches 1 line (Fr.).
1824	23 February	Hurricane. Royal College partly destroyed. Barometer 26 5·0 inches.
1828	6 March	Hurricane. Barometer 26 in. 9 lin. (Fr.).
1829	9–10 February	Hurricane. „ 27 in. 6 lin. (Fr.).
1834	20 January	Hurricane. „ 27 in. 1·6 lin. (Fr.).
1836	5–6 March	Hurricane. „ 28·230 in. (Englh).
1840	9–10 April	Storm. „ 29·04 „ „
1844	3–8 January	Hurricane. Great damage.
1848	7 March	Hurricane.

Table IV.—List of Hurricanes and Violent Winds in the Island of Réunion from 1733 to 1754. From Grant's 'History of Mauritius,' page 176.

Year.	Day and Month.	Remarks.
1733	10–11 December ...	Violent gale from north.
„	22 „ ...	Very strong wind from the south.
1734	9 January	Violent wind from the east, which continued to the 15th, when it changed to the west.
„	25–29 „	Violent wind, with heavy rain.
„	13 March	Strong gale in the offing, which was rather violent at Mauritius.
1735	26 January	Violent wind began at west and changed to east on the 27th.
1736	22–24 „	Violent wind and rain.
„	7 February	Violent gale.
1737	28–29 January	Very violent wind.
„	4 April	Strong gale.
1738	13–14 February	Strong gale from S.E. to S. and S.W.
1739	12 January	Partial gale from west.
„	22 March	Strong gale from northward.
1740	21–22 January	Strong gale from south to N.E.
„	28 February	A gale at St. Denis, which was not perceived at St. Paul but by the state of the sea.
„	13 March	Strong gale from south.
1742	10 January	Strong gale from north.
1743	8–9 March	Strong gale from the south. It did more mischief at Mauritius.
1744	9–10 January	Strong gale from north, which changed to south.
1745	12 February	Strong gale from north.
1746	19–22 January	Violent gale from east to north. After a short calm the wind shifted suddenly and successively to west, east, and south.
„	16–17 February	Strong gale, which lasted a short time.
„	6 April	Terrible wind from north. A Portuguese vessel wrecked.
1747	11 January	Strong gale from N.E. Wind passed to south.
1748	No date	Strong gale.
„	28 March	Very violent gale from south.
1750	31 January	Strong gale from north. Very violent at St. Denis.
„	4 March	Partial gale.
„	18–20 „	A more violent gale.
1751	26–27 „	A more violent hurricane than any person on the island had witnessed. The wind was easterly, and occasioned very heavy devastations.
1752	4 February	Gale from E.N.E., which was not general throughout the island.
„	21 December......	Gale from north, with violent rain. Two boats destroyed.
1753	12 March	Gale from north, which greatly damaged one of the Company's vessels.
„	26 „	A gale which drove a vessel out to sea.
1754	10 January	A gale from N.E. to N.N.W., and then a sudden shift to S.W.
„	19–21 April	Gales and hurricane, which laid waste the island.

TABLE V.—Rainfall at fifteen Stations in Scotland, from 1856 to 1867.

Years.	Bressay.	Sand-wick.	Rassay.	Ardda-roch.	Castle Toward.	Stone-field.	Greenock Water-works.	Waulk Glen.	Ryat Lynn.	Bothwell Castle.	Largs.	Brisbane.	Carles-gill.	Dum-fries.	Castle New.	Sums.
	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.
1856.	27·8	27·4	53·1	57·6	39·6	52·4	45·2	39·7	38·0	26·7	41·6	48·3	50·0	31·3	39·4	618·1
1857.	33·7	34·2	83·0	60·4	44·0	50·9	49·3	35·8	34·2	22·7	38·6	40·8	45·1	33·2	32·9	638·8
1858.	32·4	34·4	73·9	71·9	44·8	63·5	50·1	44·5	43·3	26·9	42·7	49·3	55·9	37·6	25·1	696·3
1859.	50·3	44·5	74·7	75·5	45·9	66·2	61·3	53·3	48·7	32·4	47·2	51·1	58·3	36·3	34·2	779·9
1860.	36·8	41·1	57·6	72·9	47·2	51·1	51·4	41·5	39·4	26·0	44·6	48·3	60·1	41·7	40·4	700·4
1861.	41·1	41·2	86·4	86·8	65·3	65·2	64·2	58·7	55·3	25·4	62·0	55·8	60·5	46·9	39·1	853·9
1862.	45·6	34·4	79·2	85·1	62·3	73·7	62·3	58·9	56·2	38·9	54·7	59·7	65·8	41·4	29·4	847·7
1863.	43·4	39·7	90·3	77·8	57·3	80·4	62·2	54·8	52·3	30·3	54·1	55·6	57·6	36·8	29·3	821·9
1864.	42·6	33·3	67·0	70·6	46·8	55·7	44·3	44·3	43·8	25·5	42·8	48·9	54·7	30·6	37·8	688·7
1865.	32·1	34·2	56·5	60·8	43·9	55·8	48·2	35·5	35·8	23·7	39·8	44·8	46·8	27·7	33·4	619·0
1866.	36·7	41·6	76·9	89·3	63·8	86·0	66·9	55·9	52·5	33·8	54·7	55·8	67·5	36·4	33·6	851·4
1867.	35·1	39·4	67·5	70·5	55·0	72·5	65·8	45·6	42·8	27·6	44·0	50·2	53·5	34·5	33·4	757·4

TABLE VI.—Rainfall at fifteen additional Stations in Scotland, from 1856 to 1867.

Years.	Aberdeen.	Arnhall.	Arbroath.	Hillhead.	Craigton.	Scone Palace.	Stanley.	Deanston House.	Lanrick Castle.	Glencosse.	Edinburgh.	Inveresk.	Haddington.	Smeaton.	Hunston.	Sums.
	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.
1856.	43·8	30·8	32·3	39·4	39·9	28·5	31·7	36·7	41·2	40·8	28·5	29·8	28·5	25·6	31·7	509·2
1857.	27·0	32·5	24·7	32·0	32·5	23·9	24·5	35·5	39·4	36·1	24·9	25·6	28·2	27·1	28·2	442·1
1858.	28·9	30·3	24·3	27·4	28·3	27·7	28·8	40·4	46·9	27·6	24·3	23·6	23·2	21·2	24·0	426·9
1859.	32·0	29 6	25·4	27·5	27·7	26·8	27·6	43·8	49·8	33·4	25·9	25·3	24·7	19·9	23·9	443·3
1860.	34·6	38·8	30·2	37·4	37·6	28·7	31·1	37·3	45·1	29·6	33·4	31·9	27·3	21·6	32·8	497·6
1861.	30·9	40·8	29·7	35·5	34·9	31·5	34·6	45·0	53·3	38·0	28·6	28·5	25·9	24·2	25·7	507·1
1862.	30 8	36·2	31·3	37·3	38·2	34·7	34·1	51·5	57·7	42·7	33·9	32·9	29·9	27·5	31·7	550·4
1863.	26·1	27·8	24·7	28·4	28·8	26·9	27·7	44·5	30·4	39·3	25·6	29·1	23·0	24·8	21·5	448·6
1864.	32·6	36·0	34·0	40·8	40·8	28 2	28·6	41·9	44·8	35·8	28·1	29·8	26·1	29·5	36·1	513·1
1865.	30·1	34·7	27·9	33·9	33·4	28·8	27·5	33·7	36·7	34·6	23·6	27·8	27·5	26·1	26·2	452·5
1866.	31·2	32·6	25·7	34·1	33·8	29·3	30·8	49·7	57·2	38·5	27·2	28·9	24·8	24·2	21·9	489·9
1867.	30·6	34·1	30·4	35·5	33·9	27·2	27·9	44·2	42·8	37·3	31·0	31·1	27·0	28·2	27·4	488·6

TABLE VII.—Rainfall at ten Stations on the Continent of Europe, from 1856 to 1867.

Years.	Genoa.	Siena.	Christiania.	Lyons.	Plessis Grammoin.	Leghorne.	Christiansund.	Utrecht.	Lille.	Tiflis.	Sums.	Means.	Means.
	millim.	millim.	millim.	millim.	millim.	millim.	millim.	millim.	millim.	millim.	millim.	millim.	inches.
1856	1536	388	592	660	441	859	913	764	706	308	7167	717	28·3
1857	1194	638	503	650	744	987	812	488	530	445	6991	699	27·5
1858	1246	561	517	693	613	893	912	579	469	620	7103	710	27·9
1859	1239	388	538	730	1073	1082	708	691	720	566	7735	773	30·4
1860	1248	698	768	734	947	943	560	710	991	575	8174	817	32·2
1861	717	595	608	611	685	612	981	673	702	428	6612	661	26·0
1862	1392	1049	663	705	750	1120	830	549	642	496	8196	820	32·3
1863	1135	869	585	658	741	956	545	515	627	485	7116	712	28·0
1864	1203	906	500	654	791	816	835	517	517	495	7234	723	28·5
1865	1269	768	440	613	964	831	1042	710	728	547	7912	791	31·1
1866	1149	703	517	637	983	511	677	729	792	527	7225	722	28·5
1867	1567	617	604	509	826	696	599	695	915	444	7472	747	29·4

TABLE VIII.—Rainfall at ten Stations in Prussia, from 1856 to 1867.

Years.	Kœnigsberg.	Münster (Westphalia).	Claussen.	Stettin.	Putbus.	Wustrow.	Schönberg.	Heinrichshagen.	Prenzlau.	Lübenow.	Sums.	Means.	Means.
	L.	L.	L.	L.	L.	L.	L.	L.	L.	L.	L.	L.	inches.
1856	166	353	196	260	234	208	298	214	160	217	2306	231	20·5
1857	144	377	176	201	165	110	171	153	163	187	1847	185	16·4
1858	201	268	182	167	187	112	241	158	138	186	1840	184	16·3
1859	250	257	198	185	221	188	271	226	175	219	2190	219	19·4
1860	286	272	212	190	274	159	386	206	206	229	2420	242	21·5
1861	213	270	215	238	216	202	304	163	222	236	2279	228	20·2
1862	256	298	171	229	244	180	258	147	188	213	2184	218	19·4
1863	409	306	204	200	213	162	246	203	170	220	2333	233	20·7
1864	215	325	214	196	212	128	242	213	166	223	2134	213	18·9
1865	272	362	186	176	179	153	178	166	139	179	1990	199	17·7
1866	372	358	238	248	238	194	314	241	166	255	2624	262	23·3
1867	273	336	349	272	279	248	368	246	251	270	2892	289	25·7

TABLE IX.—Rainfall at eleven Stations on the Continent of Europe, from 1856 to 1867.

Years.	Bremen.	Tilsit.	Arnstadt.	Breslau.	Stutt-gart.	Boden-bach.	Prague.	Krems-münster.	Milan.	Peters-burg.	Klagen-furt.	Sums.	Means.	Means.
	millim.	millim.	millim.	millim.	millim.	millim.	millim.	millim.	millim.	millim.	millim.	millim.	millim.	inches.
1856	670	555	490	347	679	547	379	1138	1003	310	1027	7145	649	25·5
1857	395	481	404	421	436	518	378	789	821	320	529	5492	499	19·7
1858	406	550	464	595	554	578	395	1019	996	301	771	6629	603	23·7
1859	697	605	464	626	613	563	486	1060	1127	401	969	7611	692	27·2
1860	984	698	587	623	616	692	523	978	994	389	1005	8089	735	28·9
1861	704	853	402	597	549	664	419	866	706	457	687	6994	636	25·0
1862	632	618	694	521	601	620	480	1109	1107	344	847	7573	688	27·1
1863	704	686	563	535	511	628	374	793	936	422	864	7016	638	25·1
1864	499	733	452	445	452	446	240	1032	751	525	1207	6782	617	24·2
1865	447	542	443	531	456	446	307	867	731	465	726	5961	542	21·3
1866	597	893	489	584	611	604	445	1232	792	670	1067	7984	726	28·6
1867	821	1055	563	637	674	830	394	1429	860	639	1084	8986	817	32·2

Fifth Report on Earthquakes in Scotland, drawn up by Dr. Bryce, *F.G.S. The Committee consists of* Dr. Bryce, *F.G.S.*, Sir W. Thomson, *F.R.S.*, J. Brough, G. Forbes, *F.R.S.E.*, D. Milne-Holme, *F.R.S.E.*, *and* J. Thomson.

The period of extraordinary earthquake disturbance in various parts of Scotland recorded in last year's Report has been succeeded by one of entire quiescence. Neither in the Comrie district, where the disturbances have been in time past both most frequent and severe, nor in other tracts of country occasionally agitated, has any earthquake movement been known to occur during the year, such as either to excite the attention of any one or to affect the instruments.

The seismometer belonging to the Association, placed in the tower of Comrie parish church, is maintained in a state of efficient action, and carefully observed from time to time; and a meteorological record is kept in the house of a local member of the Committee, whose residence is in the immediate neighbourhood.

As an additional indicator and check upon the seismometer, a set of upright cylinders are now to be placed in a separate building arranged as suggested by Mr. Mallet, and of the size and form which he recommends. A site for this building has been most kindly granted by Peter Drummond, Esq., of Dunearn, near Comrie, on the private grounds which surround his residence. The distance from the parish church is about half a mile, and the site upon a rock through which any vibrations that occur will be freely communicated from the supposed centre of disturbance, situated among like rocks about two miles towards the N.W. This building is to be immediately proceeded with.

In closing this brief Report the Committee have to refer with the deepest regret to the lamented death of Mr. Peter Macfarlane, which occurred in June last. Mr. Macfarlane for many years had charge of the instruments at Comrie; and the Committee have had frequent occasion to refer to his untiring zeal and watchfulness in conducting this inquiry, and to speak in terms of high commendation of the ingenious mechanical contrivances which he was enabled to bring to bear upon the methods of observing.

Report of the Committee appointed to prepare and print Tables of Wave-numbers, the Committee consisting of Dr. Huggins, *F.R.S.*, J. N. Lockyer, *F.R.S.*, Dr. Reynolds, *F.R.S.*, G. J. Stoney, *F.R.S.*, W. Spottiswoode, *F.R.S.*, Dr. De La Rue, *F.R.S.*, *and* Dr. W. M. Watts.

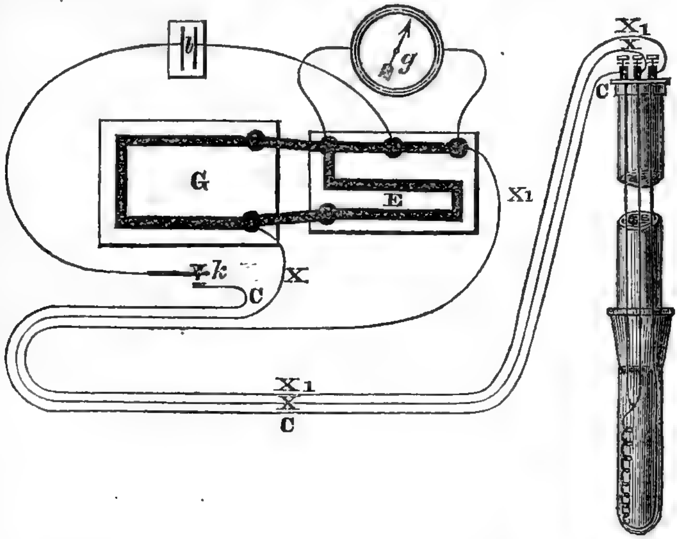
The work of this Committee is in progress, and the Committee hope to be in a position to make a full report at the next Meeting of the Association. Under these circumstances they ask to be reappointed.

Report of the Committee, consisting of Prof. A. W. Williamson, *F.R.S.*, Prof. Sir W. Thomson, *F.R.S.*, Prof. Clerk Maxwell, *F.R.S.*, Prof. G. C. Foster, *F.R.S.*, F. A. Abel, *F.R.S.*, Prof. Fleeming Jenkin, *F.R.S.*, C. W. Siemens, *F.R.S.*, *and* Mr. R. Sabine, *appointed for the purpose of testing the new Pyrometer of* Mr. Siemens.

Four pyrometers, numbered by the makers 404, 411, 414, and 445 respectively, have been supplied for the purposes of the Committee by Dr. Siemens during the course of the experiments. In all the instruments the part by which indications of change of temperature are given is identical, and consists of a length of fine platinum wire doubled back on itself, and coiled upon a cylinder of refractory fire-clay. The ends of the coil are fastened to stout platinum wires of such a length that their further extremities never reach a very high temperature, and these in their turn are connected by copper wires with binding-screws on the outside of the case of the pyrometer. The copper wires are enclosed in a stout tube of wrought iron, about 3·5 centimetres in diameter and about 120 centimetres long, which projects from the furnace or other space whose temperature is required, and forms a handle and support for the whole instrument. The part to be inserted in the furnace (namely, the coil of platinum wire) is protected by a case or sheath, which is fastened by screws to one end of the iron tube. In pyrometer No. 404 (which, it is understood, was constructed according to the plan usually adopted by Messrs. Siemens Brothers previously to the experiments of the Committee) this sheath was made of a piece of wrought-iron tubing closed at one end, and the fire-clay cylinder supporting the platinum coil was inserted in it without any further protection, beyond a packing of asbestos, employed to prevent it shifting or being injured by shaking. Pyrometers Nos. 411 and 414, besides an outer sheath of wrought iron similar to that of 404, had a piece of stout platinum foil wrapped tightly round the fire-clay cylinder, but of course not touching the coil. In all other essential respects they were exactly like No. 404. In No. 445, instead of a wrought-iron sheath, a platinum tube closed at one end was used to enclose the pyrometric coil, so that in this instrument, although it had the usual long stem of wrought iron, no part of the iron was ever exposed to a red heat; otherwise, it was just like the others. In all cases the conducting-wires, where they pass up the stem of the instrument, are kept from contact with it or with each other by being inserted in clay tubes like tobacco-pipe stems.

The indications depend on the changes which the electrical resistance of the platinum coil undergoes when its temperature is altered. In order to avoid the errors that might otherwise arise from the heating of the leading wires connecting the pyrometer with the measuring-apparatus, the undivided current of the testing-battery is conveyed by a wire, which passes down the stem of the instrument, and is denoted in the diagram by C, to the beginning of the pyrometer-coil, where it divides into two parts, one of which, after traversing the coil, is conveyed up the stem and back to the battery by a wire marked X_1 in the diagram, while the other part is conveyed by a precisely similar wire (X) to the standard against which the coil is to be measured. Thus, in the comparison, the resistance of the wire X_1 acts as an addition to that of the pyrometer-coil, and that of the wire X as an equal addition to the resistance of the standard. To insure that this compensation between the resistances of the leading wires is as accurate as possible, the three wires,

C, X, and X_1, are not only taken of the same length and gauge, but are insulated with a covering of india-rubber and tape and made into a cable of



G. Resistance-coils.	*b*. Testing-battery.
E. Platinum-silver resistance-coils.	*g*. Galvanometer.
	k. Key.

three strands, so that they are all of them exposed to similar conditions as to temperature, &c.

The most important points to ascertain, in relation to the applicability of Siemens's pyrometer to the purposes for which it is intended, were how nearly the resistance of the coil is constant at a given temperature, and, in case of its being found to be permanently altered by exposure to high temperatures, to determine the extent of such alterations. The investigations of the Committee have been confined to these two points. The whole of the measurements have been made in the Physical Laboratory of University College, London, by Professor G. C. Foster, or his assistant, Mr. W. Grant, or else by students working in the laboratory under Professor Foster's supervision. The thanks of the Committee are specially due to Mr. Charles Law and to Mr. O. J. Lodge for their valuable aid thus rendered. The method adopted was that of the differential resistance-measurer. Two sets of resistance-coils, both of them adjusted to the British-Association standard, were available for the measurements. One of them, made of platinum-silver wire, by Messrs. Elliott Brothers, gave any whole number of ohms from 1 to 10,000; the other, of very thick German-silver wire, by Mr. Grant, gave any whole number from 1 to 200. The resistance of all the pyrometers was marked upon them by the makers as being equal to 10 Siemens's mercury units at 0° C., and at the highest temperature to which any of them was exposed during the experiments, the resistance never rose beyond about 36 ohms; hence the resistances to be measured always lay within the range of the German-silver coils. In order to be able to estimate fractions of a unit, the following method was adopted:—after the smallest whole number whose resistance exceeded that of the pyrometer had been found on the German-silver coils, the other set (Elliott's) were connected in parallel circuit with these, so as to act as a "shunt," and

the resistance was altered until the balance was got as accurately as possible. It was found that in this way changes of resistance amounting to 0·001 ohm, or to about $\frac{1}{10000}$ of the quantity to be measured, could generally be detected without much difficulty. When measurements were made at atmospheric temperatures, the pyrometers were always immersed in water nearly up to the junction of the sheath surrounding the coil with the stem, and were placed in the water at least an hour before the measurement was made. Owing, however, to the conductivity of the mass of iron forming the stem, it was impossible to insure that the pyrometer-wire was even nearly at the same temperature as the water, if this differed much from the temperature of the air in the laboratory; and consequently it was thought better not to attempt to get measurements at a fixed temperature, but to make the determinations as nearly as might be at the temperature of the laboratory, and to reduce the results to a fixed temperature by calculation. As 10° C. was approximately the mean temperature at which the measures were actually taken, this was adopted as the temperature of reference.

The formula employed for correcting the observations for temperature was obtained as follows:—A piece of the same German-silver wire as that of which the 10-ohm coil was made in the set of coils used was immersed in water and its resistance measured, in one experiment at 17°·6 and 100° C., and in another, with a slightly different arrangement of the apparatus, at 18° and 100°. These determinations gave for the value of a in the formula

$$\gamma_\theta = \gamma_{10}[1 + a(\theta - 10)],$$

where θ is the temperature of the wire, γ_θ the observed resistance at $\theta°$, and γ_{10} the resistance at 10°, the values 0·000306 and 0·000312 respectively. The mean value 0·000309 was adopted in subsequent calculations. On the other hand, the following determinations were made with one of the pyrometers, No. 404:—

(1) Temperature of water surrounding pyrometer =18°, temperature of German-silver coils =19°·1. Resistance $= \frac{11 \times 400}{11 + 400} = 10·7056$ in terms of German-silver standard at 19°·1.

(2) Temperature of water =91°·6, temperature of standard =19°·8. Resistance in terms of standard at 19°·8 $= \frac{13 \times 1040}{13 + 1040} = 12·840$.

(3) Temperature of water =93°·3, temperature of standard =20°. Resistance in terms of standard at 20° $= \frac{13 \times 1500}{13 + 1500} = 12·888$.

(4) Temperature of water =18°, temperature of standard =18°·8. Resistance in terms of standard at 18°·8 $= \frac{11 \times 401}{11 + 401} = 10·7063$.

The conditions of experiments 1 and 4 and 2 and 3 respectively were so nearly identical, that each of these pairs was combined to give a single mean; this gave—

Resistance at 18° in terms of standard at 18°·95 =10·7060, whence resistance at 18° in terms of standard at 10°=

$$10·706(1 + 8·95 \times 0·000309) = 10·7356. \quad . \quad . \quad . \quad . \quad (1)$$

Resistance at 92°·45 in terms of standard at 18°·9 =12·864, whence resistance at 92°·45 in terms of standard at 10°=

$$12·864(1 + 9·9 \times 0·000309) = 12·8994. \quad . \quad . \quad . \quad . \quad (2)$$

Combining the values (1) and (2), we get for the value of b in the equation

$$R_t = R_{10}[1+b(10-t)],$$
$$b=0\cdot002764,$$

and consequently the formula for the reduction of observations to 10° becomes

$$R_{10,\,10}=R_{t\theta}\frac{1+0\cdot000309(\theta-10)}{1+0\cdot002764(t-10)},$$

where θ is the temperature of the air inside the box of German-silver resistance-coils, t the temperature of the water surrounding the pyrometer, $R_{t\theta}$ the observed resistance, and $R_{10,\,10}$ the value which would have been found if both standard and pyrometer had been at 10°.

The same correction was found also to apply to Nos. 411 and 414; but No. 445 appears to have been made with a different quality of platinum wire, for its resistance varied with changes of temperature at a perceptibly more rapid rate. Measurements of its resistance made at 100°·5 and at 9°·45 (mean of 9°·25 and 9°·65) gave for the correcting factor the value $b=0\cdot00307$, and hence the formula for correcting the measurements with this pyrometer was

$$R_{10,\,10}=R_{t\theta}\frac{1+0\cdot000309(\theta-10)}{1+0\cdot00307\ \ (t-10)}.$$

The course of testing to which each pyrometer was subjected consisted in heating it repeatedly to redness and determining its resistance at the atmospheric temperature after each heating. The source of heat most often used was the laboratory fire in an open grate without blower; but in some of the later experiments a small Hofmann's gas combustion-furnace, with three rows of clay burners, was employed. Rough measurements of the resistance of the pyrometers were made while they were in the fire in order to find out approximately how long the temperature continued to rise, and whether it was about the same in the different experiments.

It will be seen from the Tables of results which follow that, on the whole, the later measurements agree better with each other than those made at the beginning of the trials. This is no doubt to a great extent a natural result of practice in the use of the methods*, but it is also probably due in part to the greater sensibility of the galvanometer employed in the more recent experiments. The galvanometer used at first was a thin wire double-needle galvanometer by Watkins and Hill, of about 136 ohms resistance; this necessitated the use of a comparatively powerful testing-battery (three cells of Marié-Davy, zinc, carbon, sulphate of mercury), and it was consequently not always easy to prevent the resistance of the pyrometer being changed by the testing current. In all the recent experiments a reflecting galvanometer of very low resistance, by W. Grant, has been used, and a single Smee's cell has been used as the testing-battery.

The results of the measurement of each pyrometer are here given in the order in which they were made. The symbols t, θ, $R_{t\theta}$, $R_{10,\,10}$ at the head of the columns have the meanings already given. G stands for the resistance of the German-silver coils, and E for the resistance of Elliott's coils inserted in multiple arc with G to balance the pyrometer: $\frac{GE}{G+E}=R_{t\theta}$.

* One point, which was certainly not attended to sufficiently to begin with, was the importance of avoiding any thermoelectric action between different parts of the circuit, in consequence of which, when the resistance of a pyrometer was taken within about a couple of hours of its being taken out of the fire, the result sometimes differed considerably from what was found next day.

PYROMETER NO. 404.

Wrought-iron sheath; coil not otherwise protected. This pyrometer was twice heated for a short time in the fire before the first measurement was made.

Index No.	Date.	t.	θ.	G.	E.	$R_{t\theta}$.	$R_{10, 10}$.	Observer.
	1872.							
1.	22nd March.	0°	11·9°	10	259	9·628	9·911	G. C. F.
2.	,,	10·2	12	10	1140	9·913	9·914	,,
3.	23rd March.	8·5	9·9	10	870	9·886	9·927	,,
4.	,,	Red-hot.	...	34	...	34	...	,,
5.	25th March.	7	8·7	11	113	10·025	10·102	,,
6.	,,	Red-hot.	...	36	3000	35·5	...	,,
7.	,,	8·8	10·5	11	139	10·193	10·225	,,
8.	,,	8·8	10·6	11	148	10·239	10·275	,,
9.	26th March.	8	10·1	11	147	10·234	10·291	,,
10.	,,	Red-hot.	...	32	...	32	...	,,
11.	,,	9	11·3	11	153	10·262	10·294	,,
12.	27th March.	8·5	9·8	11	148·5	10·241	10·283	,,
13.	,,	Red-hot.	...	36	1500	35·2	...	,,
14.	,,	9·5	11·15	11	158	10·284	10·295	,,
15.	,,	9·6	11·3	11	160	10·292	10·307	,,
16.	28th March.	10·5	11·5	11	166	10·316	10·307	,,
17.	,,*	11·3	12·1	11	181	10·422	10·309	,,
18.	7th August.	18	19·1	11	400	10·7056	10·504	,,
19.	8th August.	18	18·8	11	401	10·7063	10·503	,,
	1873.							
20.	21st July.	20·1	21·5	11	393	10·7005	10·447	,,
21.	25th Oct.	10·5	13	11	222	10·481	10·476	,,
22.	27th Oct.	10·5	13·5	11	221	10·478	10·475	C. L.
23.	,,	Red-hot.	...	34·5	...	34·5	...	,,
24.	29th Oct.	8·5	11·5	11	247	10·531	10·578	,,
25.	,,	Red-hot.	...	...	...	34	...	,,
26.	30th Oct.	8·5	12	11	231·5	10·501	10·551	,,
27.	,,	Red-hot.	...	...	...	34	...	,,
28.	3rd Nov.	10·0	13·0	11	298·5	10·609	10·618	,,
29.	,,	Red-hot 4 hours.	...	...	...	33	...	,,
30.	5th Nov.	11	13	11	338	10·653	10·633	,,
31.	,,	Red-hot 3½ hours	...	...	...	35	...	,,
32.	6th Nov.	11·5	13·75	11	573·5	10·793	10·761	,,
33.	10th Nov.	10	13	11	489	10·758	10·760	,,
	1874.							
34.	12th August.	17·22	18	11	1570	10·9235	10·737	W. G.
35.	13th August.	16·82	17·8	11	1385	10·913	10·737	,,

PYROMETER NO. 445.—*Coil surrounded by platinum sheath.*

Index No.	Date.	t.	θ.	G.	E.	$R_{t\theta}$.	$R_{10, 10}$.	Observer.
	1874.							
1.	3rd March.	10·4°	13·0°	11	124·7	10·108	10·105	O. J. L.
2.	,,	Red-hot 2 hours.	...	...	...	35·5	...	,,
3.	4th March.	10·25	11·5	11	121	10·083	10·080	,,
4.	,,	Red-hot 4 hours.	...	...	...	35·5	...	,,
5.	5th March.	10·3	11·4	11	119	10·069	10·064	,,
6.	10th March.	9·25	11·0	11	116·25	10·049	10·075	,,
7.	,,	9·65	11·4	11	117·5	10·058	10·074	,,
8.	11th March.	Red-hot 4 hours.	...	...	...	36·8	...	,,
9.	,,	9·4	10·4	11	115·6	10·044	10·064	,,
10.	12th March.	7·0	8·0	11	108	9·983	10·070	,,
11.	,,	10·0	8·2	11	119·7	10·074	10·069	,,
12.	,,	9·7	8·4	11	118·5	10·066	10·070	,,
13.	12th August.	17·23	18·0	11	148	10·239	10·040	W. G.
14.	13th August.	19·91	17·9	11	146	10·229	10·040	,,

Note.—A gas-furnace was employed for experiment 19 with pyrometer 414, and for experiments 2 and 4 with pyrometer 445. In all other cases the source of heat employed was a common open fire.

* After this date No. 404 was used for some time by Professor Williamson, and was heated many times to moderate redness.

Pyrometer No. 411.

Wrought-iron sheath; coil protected by casing of platinum foil.

Index No.	Date.	t.	θ.	G.	E.	$R_{t\theta}$.	$R_{10°, 10°}$.	Observer.
	1873.							
1.	21st July.	20°·0	21°·3	11	146	10·229	9·988	G. C. F.
2.	„	Red-hot.	...	31	...	31	...	W. G.
3.	22nd July.	22·2	23·3	11	415	10·716	10·409	G. C. F.
4.	29th Oct.	9	11·7	11	190	10·398	10·433	C. L.
5.	„	Alternately heated to redness and cooled four times.	...	...	...	...	...	„
6.	30th Oct.	8·5	12·0	11	229·5	10·454	10·504	„
7.	„	Red-hot 4 hours.	...	...	...	...	...	„
8.	3rd Nov.	10	13·3	12	139·5	11·049	11·053	„
9.	„	Red-hot, a small quantity of red oxide of iron having been put inside sheath.	...	...	...	...	...	„
10.	5th Nov.	12	13·0	12	157·5	11·150	11·099	„
11.	„	Red-hot 4 hours.	...	...	...	...	...	„
12.	6th Nov.	11·5	13·75	12	280·5	11·508	11·467	„
	1874.							
13.	12th August.	17·23	18·[illegible]	12	1190	11·880	11·676	W. G.
14.	13th August.	16·9	17·8	12	885	11·840	11·646	„

Pyrometer No. 414.

Wrought-iron sheath; coil protected by a casing of platinum foil, which was removed on 25th October, 1873.

Index No.	Date.	t.	θ.	G.	E.	$R_{t\theta}$.	$R_{10°, 10°}$.	Observer.
	1873.							
1.	23rd Jan.	9°·6	12°·8	10	990	9·900	9·920	G. C. F.
2.	25th April.	9·5	Not taken.	10	1300	9·924	...	„
3.	„	Red-hot.	...	...	...	32	...	„
4.	21st July.	20·0	21·4	11	195	10·413	10·169	„
5.	„	Red-hot.	...	...	...	35 nearly	...	W. G.
6.	22nd July.	21·8	22·8	11	472	10·749	10·462	G. C. F.
7.	25th Oct.	10	13·25	11	206·5	10·444	10·454	„
8.	29th Oct.	9	11·7	11	198	10·421	10·455	C. L.
9.	„	Red-hot 4 hours.	...	...	...	36	...	„
10.	30th Oct.	8·5	12·0	11	100·5	10·881	10·923	„
11.	„	Alternately heated and cooled four times.	...	...	...	...	...	„
12.	3rd Nov.	10	13·0	11 12	8300 130·5	10·989 10·985	mean 10·997	„
13.	5th Nov.	11·25	13·9	12	134·5	11·017	10·992	„
14.	6th Nov.	Red-hot 4 hours.	...	...	...	...	...	„
15.	10th Nov.	10·25	13·0	12	147·5	11·097	11·100	„
	1874.							
16.	5th March.	10·7	12·5	12	144	11·077	11·064	O. J. L.
17.	„	10·9	12·5	12	145	11·083	11·064	G. C. F.
18.	10th March.	9·0	10·7	12	136·5	11·030	11·063	O. J. L.
19.	„	Red-hot 5 hours.	...	...	...	33·3	...	„
20.	11th March.	7·5	9·9	12	134	11·014	11·090	„
21.	„	8·4	10·0	12	137·5	11·037	11·086	„
22.	„	9·4	8·7	12	143·8	11·076	11·090	„
23.	12th August.	17·23	18·0	12	189	11·284	11·090	W. G.
24.	13th August.	16·9	17·9	12	186	11·273	11·089	„

From the results shown in the Tables it appears that the effect of repeated exposure to a red heat for some hours was to cause a considerable permanent increase of resistance in pyrometers 404, 411, and 414; while the resistance of 445 was almost unaffected by similar treatment, the experiments showing in this case a slight fall of resistance. The following Table gives the resistance of each pyrometer at 10° before and after the series of heatings, the total change of resistance undergone by each pyrometer, and the change of temperature which would produce approximately the observed change of resistance:—

Pyrometer.	Resistance at 10° C.		Change of resistance at 10° C.	Equivalent change of temperature.
	Before heating.	After heating.		
No. 404	9·917	10·749	+0·832	+30° C.
No. 411	9·988	11·596	+1·608	+58
No. 414	9·920	11·089	+1·169	+43
No. 445	10·105	10·059	−0·046	− 1·5

The amount of permanent alteration undergone by Nos. 404, 411, and 414 would probably be considered excessive even in an instrument to be employed merely for industrial purposes; No. 445, on the other hand, though not possessing the degree of constancy which would be desirable in a scientific instrument, is probably more constant than any other pyrometer yet devised which is capable of supporting equally high temperatures, and would probably suffice for most industrial applications. The experiments that have been made do not indicate much tendency on the part of the first three pyrometers to attain a constant condition: the effect of the later heatings was not decidedly less than that of the first. They seem, however, to show that the change of resistance is due to the continued action of a high temperature rather than to alternations of high and low temperature (compare experiments 5 and 7 on No. 411, and experiments 9 and 11 on No. 414). Hence it appears probable that the change is caused by chemical rather than by physical action; and it has been suggested by Dr. Williamson that it may result from the combined action upon the platinum coil of the reducing atmosphere existing inside the iron case and the silica of the fire-clay cylinder on which the coil is wound. This suggestion is confirmed by the fact, ascertained by Professor Williamson, that platinum is readily fused, and apparently becomes alloyed with silicon, when heated in a reducing atmosphere in contact with finely divided silica. It is also in harmony with the fact that pyrometer 445, in which there was no iron in the parts exposed to the greatest heat, did not show a greater change than might be attributed to a slight annealing of the wire. Professor Williamson proposed, as a means by which the alteration of the platinum might probably be prevented, to coat the inside of the iron sheath surrounding the coil with oxide of iron, whereby the formation of a reducing atmosphere would be made impossible; and an attempt was made to test the proposal by putting some oxide of iron into the sheath of 411; it was, however, thought undesirable to let the oxide come into contact with the platinum, and the quantity which could be introduced without running a risk of its doing so was probably too small to produce the intended result; at any rate it did no perceptible good.

By comparing the results given above, it will be seen that repeated measurements of the same pyrometer, without intermediate heating, often gave almost identical results if they were made within a few days of each other;

but that measurements made after an interval of a few months, even when the pyrometer had not been heated in the mean time, sometimes differed decidedly from the results previously found. Possibly such changes may be due to alterations of the unsoldered connexions of the conducting-wires; but, whatever their cause, they would probably be met with in actual practice if the pyrometers were used during long periods of time.

Report to the Lords Commissioners of the Admiralty on Experiments for the Determination of the Frictional Resistance of Water on a Surface, under various conditions, performed at Chelston Cross, under the Authority of their Lordships. By WILLIAM FROUDE, *F.R.S.*

[A communication ordered by the General Committee to be printed *in extenso.*]

(PLATES VIII.–XII.)

Second Report.*

Chelston Cross,
13 December, 1872.

As in the Report on the subject handed in in August last, the results of the investigation will be presented under three principal aspects:—

(1) The law of the variation of the resistance, in terms of the variation of the speed.

(2) The law of the variation of the resistance, in terms of the variation in the length of the surface.

(3) The nature of the variation of the resistance, in terms of the variation in the quality of the surface.

It will be seen, however, that, as exemplified by the results now presented, no less than by those presented in the former Report, the three laws are more or less interdependent.

In this concluding part of the series it was sought to give completeness to the determination of the effect of quality, in what may be termed its practical extremes of smoothness and of roughness. The experiments comprising the completion of the trials made with a tinfoiled surface on the one hand, and one coated with rough sand on the other, represent these extremes.

The list of materials used in forming the surface includes (1) tinfoil; (2) hard paraffine, laid on thin and scraped perfectly smooth (this was also used as a substratum on which to lay the foil, the medium of adhesion being a thin coat of tallow); (3) blacklead, polished on the paraffine; (4) unbleached calico; (5) three varieties of sand, differing from one another in the coarseness of grain. The sands, of graduated fineness, were in turn sifted on to a paraffined surface, having been previously sufficiently heated to melt their way into it and become fixed there.

There was, as might be expected, some difficulty in securing identity of quality (1) throughout the length of each individual surface, and (2) (*à fortiori*) in the planes of different length. Of the smooth surfaces, the scraped paraffine, naked, was perhaps the most uniform for all lengths; of the rough

* For Preliminary Report *vide* Report of Brighton Meeting, 1872, p. 118.

ones, the calico. But in each case pains were taken to secure uniformity, and no difference of perceptible amount was permitted.

A tolerably correct perception of the different degrees of roughness obtained with the roughened surfaces will be conveyed by the full-size photographic representations (Plate XII.).

In forming all the surfaces care was taken to avoid abnormal roughness, and to eliminate the effect of thickness of cutwater and of stern-end or run, the ends of all planes being formed as shown in plate 3 of the previous Report. In the case of the calico, a fine entrance was obtained by placing a sharp tin cutwater, 1 inch long, over the seam at the front edge of the plane; the calico was also carefully closed round the tail, and a fairly fine run secured.

The results obtained are shown in full detail in the accompanying diagrams, four in number, which, as in the former Report, represent them *seriatim*, as finally reduced, in two separate forms. In one form (series 1, Plates VIII. & IX.) the abscissæ or measurements along the base line represent speed; in the other (series 2, Plates X. & XI.) they represent length of surface. The corresponding ordinates in each case represent resistance.

In the first-named series, each of the successive lengths of surface has a group of curves assigned to it, corresponding with the various qualities of surfaces, and exhibiting the law of resistance in terms of *speed* of surface.

In the second-named series, each of the successive speeds of surface has a group of curves assigned to it, corresponding with the various *qualities* of surface, and exhibiting the law of resistance in terms of *length* of surface. In each of the diagrams, curves showing the results given by a surface coated with shellac varnish are given as a standard of comparison, the former experiments having shown that this quality of surface might be regarded as in some sense a standard quality—it being easily laid on with invariable quality, and being practically identical in respect of resistance with Hay's or Peacock's composition, smooth paint, or tallow. These standard curves are copied from the diagrams which accompanied the former Report.

The planes used in the experiments were, as before, about 19 inches wide; but the resistances shown for each length are those of the entire length of surface, assuming it to be of parallel width, and to expose to the frictional action one square foot of surface per foot of length.

It will be seen that the diagrams of each form are deducible from those of the other.

The results are shown in a more compendious but necessarily less complete form in the accompanying tabular statement (p. 251).

This represents the resistances per square foot due to various lengths of surface, of various qualities, when moving with a standard speed of 600 feet per minute, accompanied by figures, in smaller type, denoting the power of the speed to which the resistances, if calculated for other speeds, must be taken as approximately proportional.

Under the figure denoting the length of surface in each case, are three columns, A, B, C, which are referenced as follows:—

A. Power of speed to which resistance is approximately proportional.

B. Resistance in pounds per square foot of a surface the length of which is that specified in the heading—taken as the mean resistance for the whole length.

C. Resistance per square foot on unit of surface, at the distance sternward from the cutwater specified in the heading.

	Length of surface, or distance from cutwater, in feet.											
	2 feet.			8 feet.			20 feet.			50 feet.		
	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.
Varnish	2·00	·41	·390	1·85	·325	·264	1·85	·278	·240	1·83	·250	·226
Paraffine	1·95	·38	·370	1·94	·314	·260	1·93	·271	·237	...	...	...
Tinfoil	2·16	·30	·295	1·99	·278	·263	1·90	·262	·244	1·83	·246	·232
Calico	1·93	·87	·725	1·92	·626	·504	1·89	·531	·447	1·87	·474	·423
Fine sand	2·00	·81	·690	2·00	·583	·450	2·00	·480	·384	2·06	·405	·337
Medium sand	2·00	·90	·730	2·00	·625	·488	2·00	·534	·465	2·00	·488	·456
Coarse sand	2·00	1·10	·880	2·00	·714	·520	2·00	·588	·490	...	...	...

Looking at the subject in its practical aspect, the results exhibited in the diagrams and tabular statement may be regarded as *literal facts*, ascertained with great care and exactness by reiterated experiments, the close mutual accordance of which was instanced and sufficiently attested by the diagrams in plate 4 in the series which accompanied the former Report, in which the points deduced immediately from the experiments are shown in connexion with the "fair lines" drawn through them; and no difficulty deserving of notice presents itself in reference to the practical employment of the results, except that, when the probable resistance of a more or less rough surface is to be estimated, discrimination must be exercised in selecting, among the qualities of surface used in the experiments, that which best serves the purpose of the intended comparison.

Looking at the subject in a speculative aspect, however, certain features of the results present perplexing anomalies.

It is true that the tabulated powers for each quality are, as may be seen, very nearly the same, whatever be the length of the surface, presenting only a slight tendency to a decrease in the "power" as the length is greater; and this difference is not unsuggestive. And again, if in each case, taking the resistance at 600 feet per minute as a basis, the resistances at other speeds be calculated from this according to the tabulated power, they will be found almost in every case to agree very closely, throughout the entire line, with those shown in the diagram; and this to a singular degree as regards what is treated as the surface of standard quality—namely, the varnished surface.

But the regularity here exhibited gives additional weight to the discrepancies which appear in other aspects of the effect of quality of surface, and some of these seem extremely anomalous; for whereas on comparing the surfaces of tinfoil and again that of scraped paraffine, both of them extremely smooth, with the slightly rougher and, consequently, more resisting varnished surface, we find that the *rougher* surface follows the *lower* power of the speed —the power being 2·0 for the tinfoil, 1·94 for the paraffine, and 1·85 for the varnish; we find, on the contrary, in the comparison between the comparatively smooth varnished surface and the far rougher and far more resisting surfaces of calico and sand, that the *rougher* surface follows the *higher* instead of the lower power of the speed, the power being 1·85 for the varnish, and 1·93 and 2·00 (in one case 2·06) for the calico and sand respectively.

The case of the tinfoil is very remarkable: with a very short plane its resistance is little more than half of that of the varnished surface; yet, possibly

owing to the combined effect of the greater power of the speed to which the resistance is proportional, coupled with its less rapid declension in terms of length of surface, with a length of 50 feet the mean resistance of the tinfoiled surface is barely less than that of the varnished surface, and its resistance per square foot at the 50th foot is the greater of the two.

It is true that this apparent anomaly probably in part depends on the fact that the coating of the longer surfaces with the foil was not so easily effected as that of the shorter, and therefore perhaps their smoothness was less perfect and their resistance somewhat increased; yet, making every reasonable allowance for this, the anomaly is still remarkable.

Again, no rational explanation presents itself of the differences in the law of variation of resistance in terms of length, exhibited by the rougher and more highly resisting surfaces. The resistance, for instance, of the medium sand alters disproportionately little towards the end of the plane, nor do any of these resistances exhibit as marked an excess of decrease in that direction as might have been expected. Partly, no doubt, this is owing to the difficulty in securing uniformity of coating; but also, it must be admitted, that the law which really governs the decrease has yet to be discovered, though it can hardly be doubted that it depends somehow on the current created by the passage of the surfaces.

I shall conclude the Report with some remarks on what appears to me to be the rationale of the declension of resistance in terms of length of surface.

It is certain that any surface which, in passing through a fluid, experiences resistance, must, in doing so, impress on the particles which resist it a force in the line of motion equal to the resistance. Now, we cannot regard a fluid as anchored to the shore or bottom by lines of tension or of thrust which are snapped or crushed by the force which causes motion; but, on the contrary, we must assume the resistance offered by the particles of fluid to be purely dynamic, and to be dependent on and correlative to their weights and the velocities imparted to them.

This being so, it is quite certain that the operating force, which (whatever be its amount) must be precisely equal to the resistance when the speed is steady, will in each unit of time, say in each second, generate a given definite amount of new momentum, estimated in the line of motion, in the system of particles on which it operates. The force must, in fact, generate somewhere and somehow in the surrounding fluid the momentum which exactly corresponds dynamically to the universal law connecting force and momentum.

That law may be expressed as follows:—

If F be the force in pounds which operates in a given direction,
W the weight operated on in pounds,
V the velocity in feet per second,
t the time of action,
g the force of gravity $=\frac{32\cdot2 \text{ ft.}}{1''^2}$,

then $V=\frac{Fgt}{W}$.

For the momentum, therefore, we have

$$WV=Fgt; \quad \ldots\ldots\ldots\ldots \quad (1)$$

and this is equally true, whether it be the result of a small force acting

on a large mass, or *vice versâ*, or of a single force acting on a succession of masses.

The expression, therefore, quantifies the momentum which must be generated in each second in the surrounding fluid, by the transit of a surface the resisting force of which is F. In some shape or other, there must be left behind it, in each second, new momentum to that extent, existing either in the shape of a narrow and rapid current, or a broad and slow one, or one of graduated speed and corresponding volume.

This last supposition is clearly the most reasonable one, and it is approximately in visible accordance with fact; and, without speculating on the *modus operandi* by which the motion is communicated, it becomes easy by help of this supposition to put an approximate value on the breadth of the current produced under any given circumstances.

It will be seen presently that if the surface is long, the current thus estimated must be of considerable breadth; and if this be so, instead of finding it difficult to explain why the resistance per square foot grows less as the length is increased, the perplexing question is, how the rate of declension is so slow. For a little reflection obliges us to see that it is the motion of the surface relative to contiguous particles, and not relative to distant ones, that governs the resistance; and if these contiguous particles are already possessed of considerable velocity, concurrent with that of the surface, their resisting power must plainly be impaired.

When we proceed to trace the genesis of the momentum in detail, as it must exist in the completely generated current left behind by the surface, if we select at any point an element or strip of current parallel to the line of motion, and possessing the velocity v in feet per second in that line, we see that in that element the quantity of matter newly put in motion per second will, at that point, be a portion of the strip, $(V-v)$ feet in length (that being the length left behind by the surface), while the velocity impressed on it is v; and if all the dimensions be in feet, taking the depth of the current parallel to the surface as unity, and the thickness or breadth of the element as dh (h being the distance from the plane of the surface), we shall have for the weight of the element, $dw = \acute{\omega}\,(V-v)\,dh$, $\acute{\omega}$ being the weight of a cubic foot.

Now if we assume that the current possesses a velocity $=V$ at the plane of the surface (that is to say, that the particles in contact with the surface have the same speed as the surface), and that where $h=H$, then also $v=0$, the intermediate gradation of speed being uniform, we have

$$v=\frac{V(H-h)}{H};$$

hence

$$dw=\acute{\omega}V\frac{h}{H}dh;$$

and if M be the momentum,

$$dM=vdw=\frac{\acute{\omega}V^2}{H^2}(H-h)hdh;$$

$$\therefore\ M=\frac{\acute{\omega}V^2}{H^2}\left(\frac{Hh^2}{2}-\frac{h^3}{3}\right);$$

and if $h=H$, we have, for the complete current,

$$M=\acute{\omega}V^2\frac{H}{6}; \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

and this must equal Ft, as given in equation (1);
or, since $t=1''$,

$$Fg=\acute{\omega}V^2\frac{H}{6};$$

or, since salt water weighs 64 lbs. per cubic foot, so that $\acute{\omega}=64$, and $g=32{\cdot}2$, we may write the equation with sufficient exactness

$$F=\frac{V^2H}{3},$$

or, as the extreme breadth of the current, $H=\frac{3F}{V^2}$.

If we apply this to the 50-ft. varnished surface, having a speed of 600 ft. per minute, or 10 ft. per second, which had the definite resistance of 12·5 lbs., we have

$$H={\cdot}375 \text{ ft., or about } 4\tfrac{1}{2} \text{ inches};$$

and this was not far from the truth, though, as it is not easy to obtain an exact measurement, the agreement must not be represented as more than approximate.

But if the surface had been 500 feet instead of only 50 feet in length, and if we could assume the same resistance per square foot to be retained throughout the length, the current would be 3·75 feet broad, and the velocity, to a sensible distance from the surface, would be not far short of that of the surface; and we should have to encounter the paradox that under these circumstances the surface when enveloped in a favouring current more than 3 feet in breadth, and having, for a breadth of many inches, scarcely less speed than the surface itself, would be experiencing the same resistance as when entering undisturbed water.

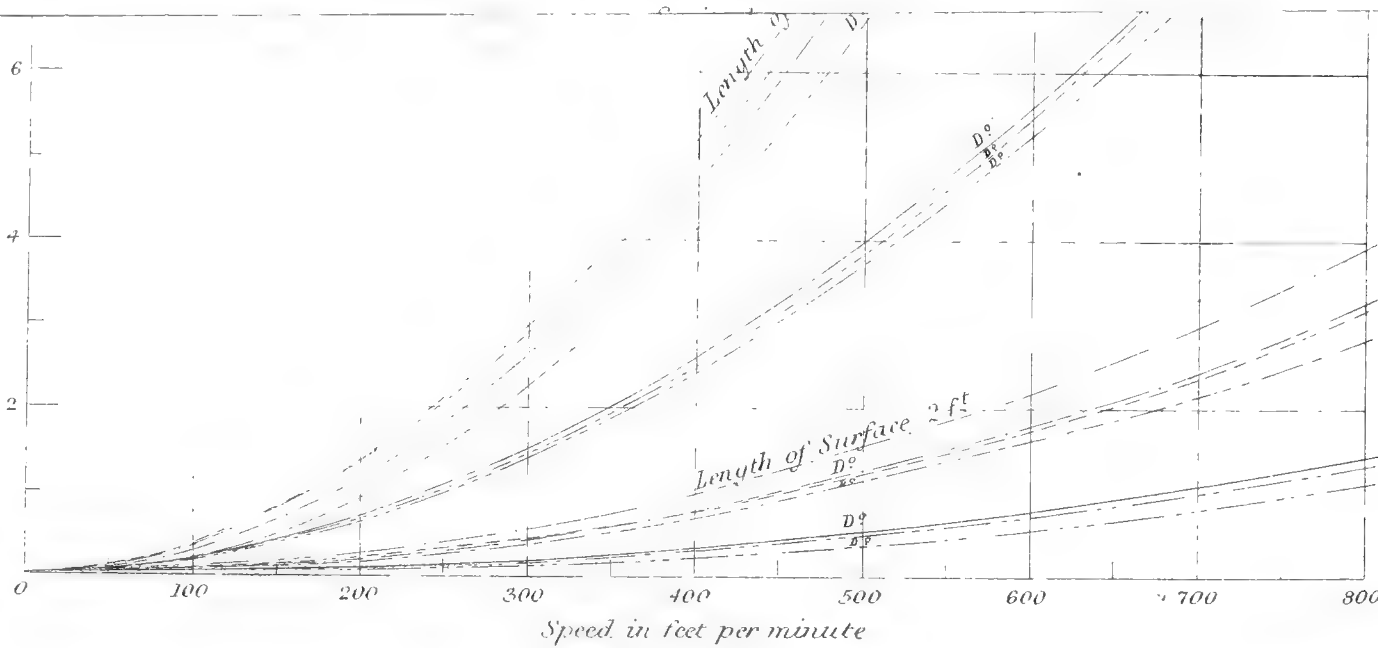
If we suppose the law of distribution of velocity through the current to be different from that assumed in the above investigation, so as to allow particles having much less velocity to be near the surface, the breadth to be assigned to the current must be on the whole much greater, and the method by which the velocity could be thus distributed would be difficult to conceive.

However, we do in fact see that the current is greatly disturbed by eddies; and these, no doubt, furnish a machinery by which the distribution of velocity is modified—the modification being of such sort that relatively undisturbed particles are being perpetually *fed* inwards towards the surface from the outer margin of the current; and it is by this agency alone that the resistance throughout the length of surface is so little reduced as these experiments prove: though, on the other hand, it seems to me certain that *unlimited* elongation of surface must nevertheless be accompanied by an *all but unlimited* reduction of resistance. At least it appears impossible to conceive a system of eddies such as to bring undisturbed particles across a current of unlimited width into close proximity with the surface, and in such quick succession, as a sustained scale of resistance would imply.

Practically, however, although these experiments do not directly deal with surfaces of greater length than 50 feet, they afford data sufficient to enable us to predict with tolerable certainty the resistance of surfaces of such lengths as

Experiments on Surface Friction:

Total Resistances of surfaces of various lengths, reduced to one foot of area per foot run.

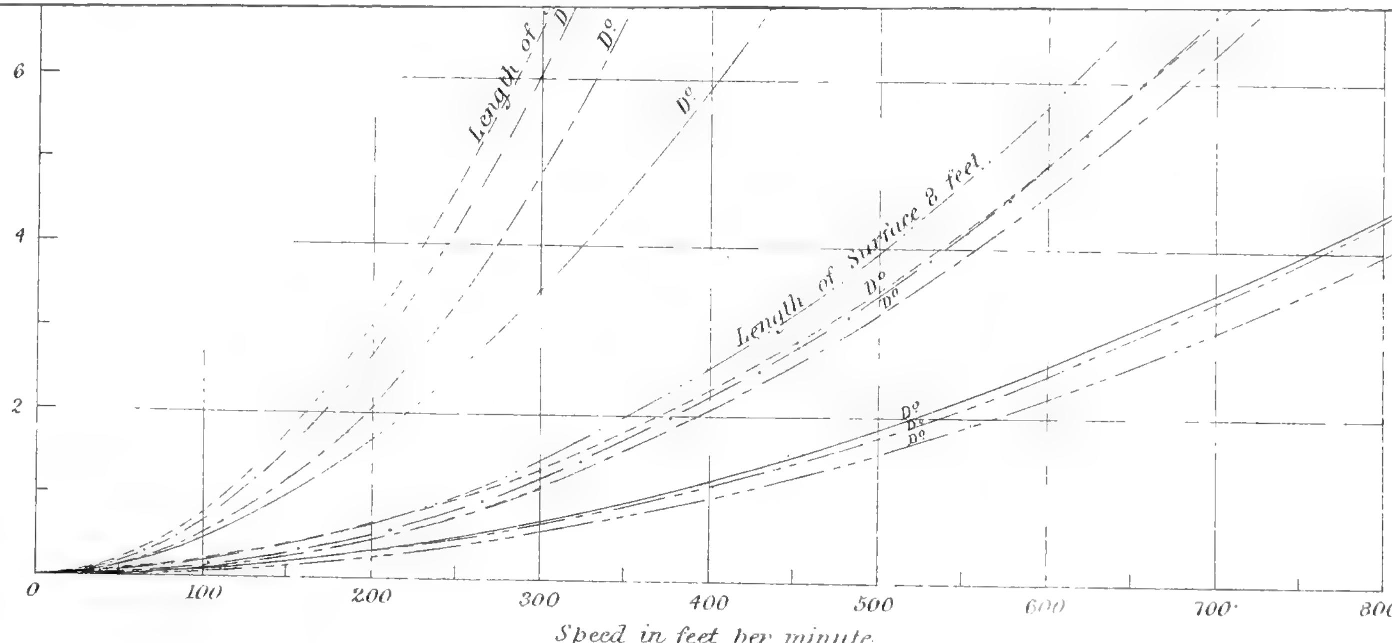


Engraved by Chas. Ingram.

Experiments on Surface Friction.

Total Resistances of surfaces of various lengths, reduced to one foot of area per foot run.

Series. 1.



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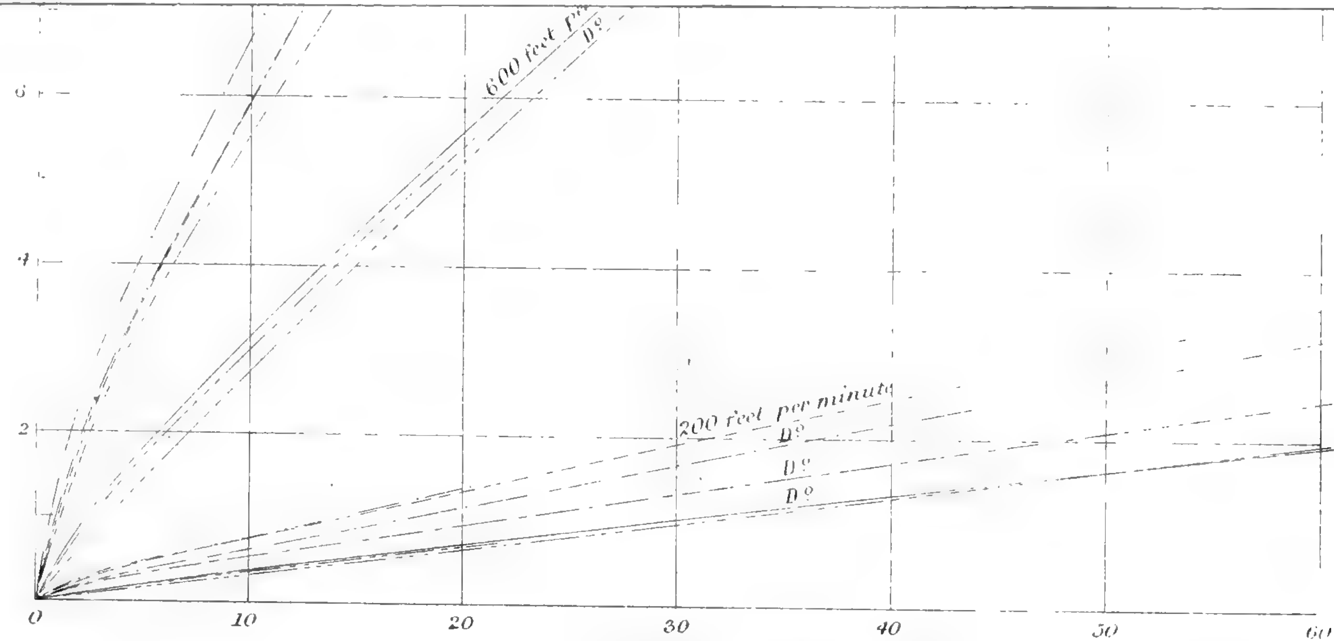
Experiments on Surface Friction.

Total Resistances of surfaces of various lengths, reduced to one foot of area per foot run

Series 2.



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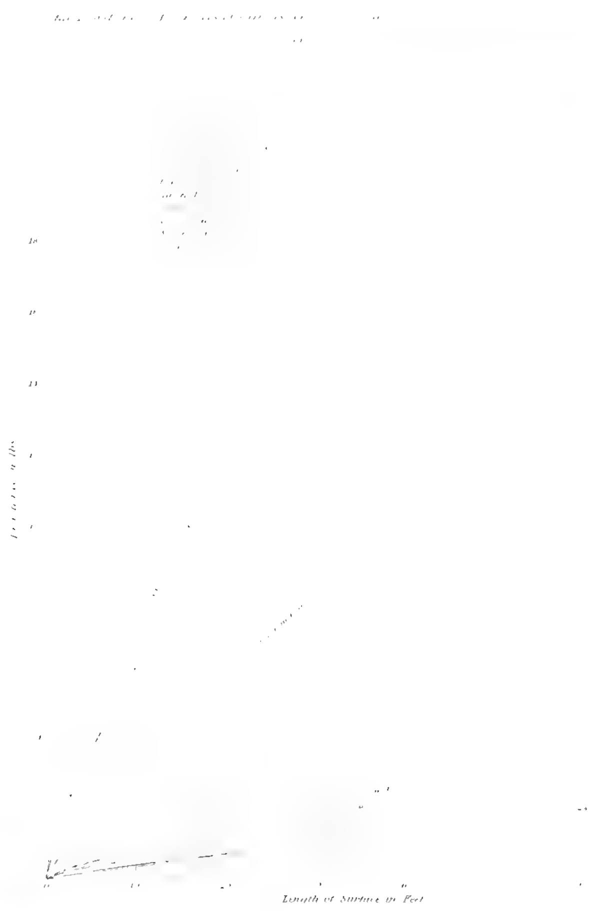
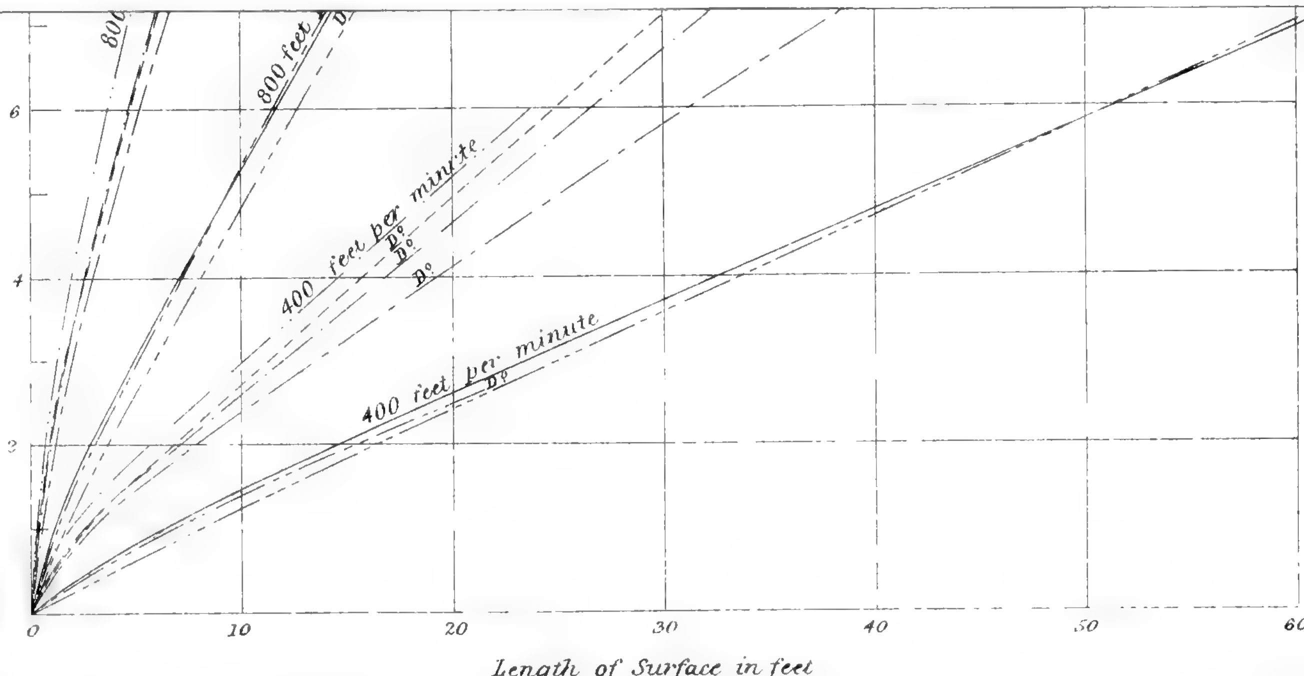

Length of Surface in Feet

Experiments on Surface Friction.

Total Resistances of surfaces of various lengths, reduced to one foot of area per foot run.

Series 2.

REFERENCES.



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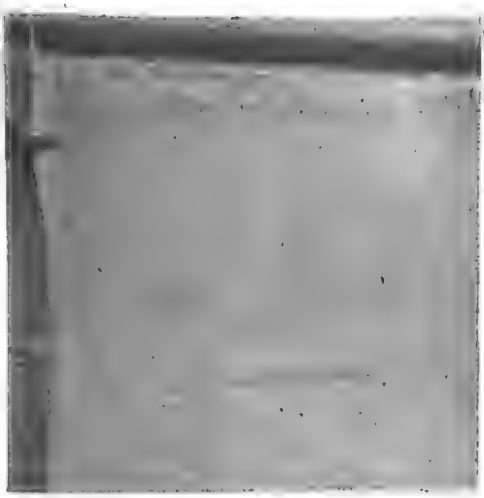
Experiments on Surface Friction.

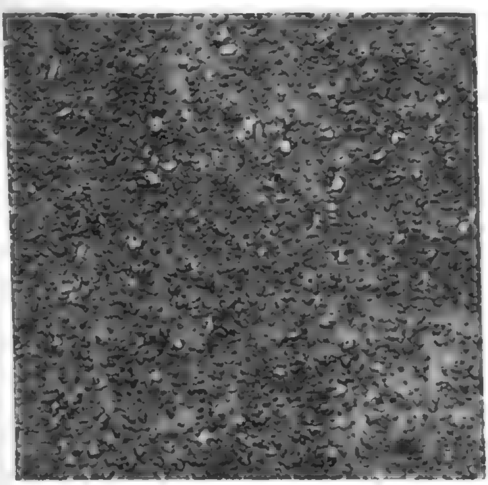
Qualities of roughened Surfaces.

Calico.

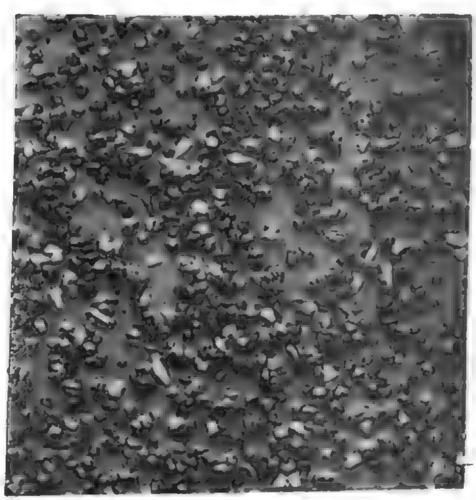


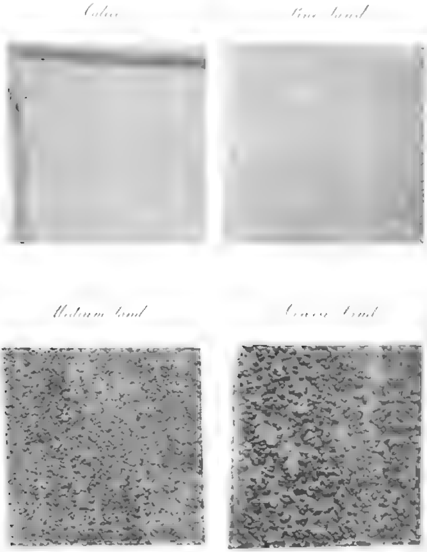
Fine Sand.

Medium Sand.



Coarse Sand.




Fine sand
Medium sand
Coarse sand

are commonly met with in ships. For it is at once seen that, at a length of 50 feet, the decrease (with increasing length) of the friction per square foot of every *additional* length is so small that it will make no very great difference in our estimate of the total resistance of a surface three hundred feet long, whether we assume such decrease to continue at the same rate throughout the last two hundred and fifty feet of the surface, or to cease entirely after fifty feet; while it is in effect certain that the truth must lie somewhere between these two assumptions.

Second Report of the Committee for the Selection and Nomenclature of Dynamical and Electrical Units, the Committee consisting of Professor Sir W. Thomson, *F.R.S.*, Professor G. C. Foster, *F.R.S.*, Professor J. Clerk Maxwell, *F.R.S.*, G. J. Stoney, *F.R.S.*, Professor Fleeming Jenkin, *F.R.S.*, Dr. C. W. Siemens, *F.R.S.*, F. J. Bramwell, *F.R.S.*, Professor W. G. Adams, *F.R.S.*, Professor Balfour Stewart, *F.R.S.*, *and* Professor Everett (Secretary.)

The Committee on the Nomenclature of Dynamical and Electrical Units have circulated numerous copies of their last year's Report among scientific men both at home and abroad.

They believe, however, that, in order to render their recommendations fully available for science teaching and scientific work, a full and popular exposition of the whole subject of physical units is necessary, together with a collection of examples (tabular and otherwise) illustrating the application of systematic units to a variety of physical measurements. Students usually find peculiar difficulty in questions relating to units; and even the experienced scientific calculator is glad to have before him concrete examples with which to compare his own results, as a security against misapprehension or mistake.

Some members of the Committee have been preparing a small volume of illustrations of the C. G. S. system [Centimetre-Gramme-Second system] intended to meet this want.

On Instruments for Measuring the Speed of Ships. Memorandum of Mr. Froude's *Experiments in relation to the Pressure-Log, with a Description of the Apparatus employed*. The Committee consists of* W. Froude, *F.R.S.*, F. J. Bramwell, *F.R.S.*, A. E. Fletcher, Rev. E. L. Berthon, James R. Napier, *F.R.S.*, C. W. Merrifield, *F.R.S.*, Dr. C. W. Siemens, *F.R.S.*, H.M. Brunel, W. Smith, Sir William Thomson, *F.R.S.*, *and* J. N. Shoolbred.

(Plates XIII. & XIV.)

It seems best to begin by stating broadly the results which appear to have been established, reserving till afterwards the description of the apparatus and the details of the several experiments.

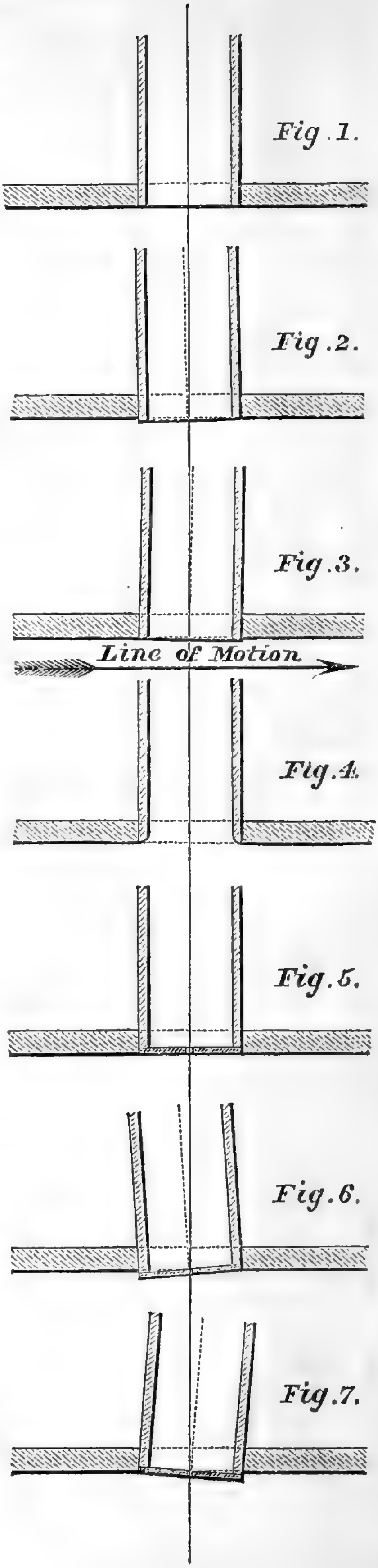
* The experiments must be regarded as strictly elementary.

(1) If a plane be moving edgeways through the water, and the end of a pipe connected with a pressure-gauge be brought square through the plane and terminates flush with the surface (fig. 1), the motion of the plane causes a small positive pressure within the pipe, amounting to about ·04 of the pressure due to the speed. If, however, the end of the pipe be not very exactly flush with the plane, this positive pressure is increased when the rearward edge is the projecting part (fig. 2), and is diminished, or even becomes negative, when the position is reversed (fig. 3). If the end of the pipe is flush with the plane, but has its internal edge slightly rounded off (fig. 4), the positive pressure caused by motion of the plane very nearly disappears.

If the end of the pipe be closed by a disk forming a smooth flush end with a small aperture in it (fig. 5), there is no appreciable positive pressure caused by the motion of the plane; nor is positive or negative pressure caused when this disk forms a slight angle with the line of motion, whether facing forward or facing sternward (figs. 6 & 7), unless the angle is considerable (say some five degrees or so), a very much larger angle than produced considerable effect of this kind with the open-mouthed pipe.

The pipe with which these results were obtained was about ½ inch diameter, and the speeds used ranged from 280 to 600 feet per minute.

(2) In a cylindrical tube projecting into the fluid at right angles to the line of motion, with the end closed but with a hole in the side, the angle of position of the neutral point, referred (that is to say, measured circumferentially from the foremost side of the cylinder) to the point where the pressure is not affected by the motion, depends considerably upon the relative diameter of the tube and the hole in it. The greater the relative diameter of the hole, the greater is the angle of position of the neutral point. Thus the angle of position of the neutral point in a tube 1·1 inch external diameter, having a $\frac{1}{20}$-inch diameter hole, seems about $40^{\circ}\cdot5$; that of the same tube with a hole



$\frac{3}{20}$ inch diameter is about 43°; and that of a tube $\frac{1}{2}$ inch diameter, with a hole $\frac{3}{20}$ inch diameter, is about 45°·5.

The position of the neutral point was also in these experiments sensibly affected by some unknown condition, dependent apparently upon the degree of projection of the tube into the fluid, and which I think may possibly have been of the nature of a vibration of the tube. Of this I will here merely say further that it prevented a precise determination of the degree to which the neutral angle is affected by close proximity of the hole to the end of the tube.

(3) The maximum positive pressure (which was obtained, of course, with the hole pointing directly in the line of motion) falls slightly short of that theoretically due to the speed, and is apparently unaffected either by the size of the tube or of the hole in it. It appears also to be unaffected by the above-mentioned unknown condition, being practically identical under all conditions, except when the hole approaches close to the end of the tube (within, say, a distance equal to the diameter of the tube), in which case the pressure is found to diminish.

(4) For some distance on either side of the neutral point the pressure decreases nearly uniformly, with uniform increments in the angular departure of the hole from the line of motion. The rate of decrease is about ·04 of the maximum positive pressure for every degree of angle. At angles of more than 50° the column was always unsteady, and it was impossible to obtain accurate measures of it; but the observations show consistently a maximum of negative pressure at somewhere about 70°, and then a decrease of between one third and one half of the maximum negative pressure between 70° and 90°. From 90° to 180° the negative pressure remains about uniform*.

The amounts of these negative pressures, besides being, as already mentioned, rather indefinite in consequence of the fluctuations of the column, are sensibly affected by the unknown condition already referred to, and therefore it is impossible to speak positively as to their absolute amount.

(5) A hole in the stopped end, instead of in the side, of the pressure-tube (the tube being set as in the experiment for side pressure) gives a considerable negative pressure, varying in amount according to the position of the hole in the disk which closes the end of the tube. In the case tried, the tube was 1·1 inch external diameter, the hole was $\frac{1}{20}$ diameter, and was eccentric in the disk by about half the radius of the tube. It was tried at a speed of 6 feet per second, corresponding with a direct pressure of ·56 foot; and the negative pressure recorded when the hole was nearest the forward edge was ·64 foot. When it was 180° from this position (*i. e.* nearest to the rearward edge) the negative pressure was ·29 foot; and this appeared to be the position of minimum negative pressure. The maximum negative pressure observed was ·67 foot, and was at 45° from the foremost position. At 90° it was ·64 foot, and at 135° was ·41 foot.

I proceed to describe the principal features of the apparatus, and the mode of trying the experiments.

The fundamental parts are as follows:—

* The diagram, Plate XIV., shows the pressure for all angles between 0° and 180° under three of the different conditions tried. The curves thus presented, between 0° and the neutral angle, somewhat resemble curves of sines. The degree of resemblance is indicated by the companion lines shown in fainter dots, and which are true curves of sines. It may be observed that the wider the neutral angle the greater is the departure from the companion curve.

(1) A covered tank or water-space, 278 feet long in all, about 228 feet of this being available for the run. The water is 36 feet wide at the surface and 10 feet deep.

(2) A railway suspended from the framed roof, dead straight and dead level, at a height of 19 inches above the water, the space between the rails being quite clear, and the rails being traversed by an endless wire rope.

(3) A small double-cylinder engine to drive the truck, fitted with a special governor, and capable of assigning to the truck a series of definite steady speeds (if required, indeed, *any* definite steady speed) between 100 feet per minute (about 1 knot) and 900 feet per minute (or about 9 knots).

The above-named elements are also the fundamental parts of the apparatus used in the experiments which I am carrying out for the Admiralty in the investigation of the resistances of ship-models of various forms at various speeds.

For the purpose of the present experiments, there was attached to the truck an additional apparatus, represented in Plate XIII.

It may be serviceable to observe at starting that, with a view to many (perhaps sufficiently obvious) points of convenience, the principle adopted in the arrangement of the pressure-gauge is one in virtue of which it might be termed a "sympiezometer"—the variations of pressure to be recorded being, however, not those of the atmosphere, but those of the pressure of the water on the open end of the instrument, that is to say, on the pressure-hole. It is true that were the pressure of the atmosphere to vary during any individual "run," that variation would enter into the result; but this is a condition which, because of its inevitably infinitesimal character, may be safely left out of the account.

The following references will assist in explaining the arrangement.

Fig. 1 (Plate XIII.).

A A, A′ A′. Longitudinal timbers of the truck-frame.

B. Transverse timber of truck-frame.

a a. A stout standard, bolted to the main cross bar.

b b. A shallow headstock (as it may be called) like that of a lathe, securely screwed to the foot of *a a*.

c c. A vertical cylindrical steel arbor, which is capable of sliding vertically through a pair of collars which revolve (without endways-motion) in the bearings afforded by the headstock. The arbor can be clamped to the lower of these collars by a pinching-screw at any level which its length permits—that is to say, with a travel of 10 inches.

d d. A sort of "chuck" or screwed hollow nozzle, to which the various pressure-pipes used in the experiments are fixed by a union collar, so as to be thus carried concentrically by the arbor. As the first step in filling the system with water, the air which this chuck contains is wholly exhausted by a mouth-pipe which leads out of the highest part of the interior.

e e. An india-rubber pipe which conveys the water to the indicating part of the apparatus. This pipe is long enough to allow the arbor to be adjusted vertically (so as to vary the depth of immersion of the pressure-hole) and circumferentially (so as to allow the hole to be presented in any required direction relative to the line of motion). The pipe leads

out of the lower part of the hollow or chamber in the nozzle, so that any bubbles of air which may enter the pressure-pipe become impounded in the upper part of the hollow, instead of rising in the pressure-pipe.

f f. The pressure-pipe. The pipe here shown is the largest of those used, and it is in the lowest possible position. The range of vertical adjustment is indicated by dotted lines.

g g. A disk 16 inches in diameter, divided to degrees, and, by a vernier, giving tenths of degrees, fixed to the lower of the two collars in which the arbor slides—the collar, namely, in which the arbor is clamped so as to define its level. The collar, with the divided disk attached to it, can be clamped in any required circumferential position, so as to secure the pressure-hole in the required position relatively to the line of motion.

h h. The glass index-tube, forming a connexion between the pressure-pipe and the vacuum-chamber, and provided with scale for reading the level at which the water stands.

j j. The vacuum-chamber. The required degree of exhaustion is produced in it by the descending leg of a siphon. It is connected at the top with the external air by a vertical india-rubber pipe, and with the siphon by a horizontal one, either of which can at pleasure be closed air-tight by a clamp.

k k. The siphon, consisting of a water-chamber and a descending pipe. The lower end of this pipe is turned upwards, and is closed by a cork while the siphon-chamber is being charged with water through an aperture with screwed stopper at the top. When the chamber is fully charged, the cork is removed and the water descends, raising the column on the other side above the top of the glass tube. The india-rubber connexion with the vacuum-chamber is then closed, and air is admitted to the latter through the india-rubber pipe at the top, until the water assumes a convenient zero-level. The vacuum-chamber is effectually "jacketed" with paraffine, so that changes of atmospheric temperature do not rapidly affect its interior.

l l. A plane surface or deck (of thin board, 14×19 inches) for restraining the surface of the water, so as to prevent the formation of waves and the consequent dissipation of pressure, and give additional stiffness to the pipe and the arbor which carries it. The deck is securely bracketed to a pair of transverse bars, carried by vertical slides which are attached to the side-frame of the truck, and which are firmly clamped when the deck is brought to the required level. The brackets which carry the deck can be adjusted on transverse bars, and are finally clamped to them (like the saddle of the rest on the bed of the lathe) when the deck has been duly adjusted to the pipe. The drawing shows the deck as fixed at its working immersion.

As the hole in the deck is necessarily large enough to admit the largest pipe, and as it is convenient that the fit should be easy while the adjustments are being made, each pipe is provided with a detached stout plate through which it slides with a close fit, and which by a suitable arrangement is firmly clamped to the deck and blocked by wedges on all sides so as to support the pipe effectually, and, moreover, prevent the admission of air behind the pipe, which at high speeds would affect the negative pressure in the rear. To exclude the air with still greater certainty, a "wall" of tin encloses the sides and rear of the tube above the plate (acting as a water-trap), so that the hole through

which the pipe passes shall be always gorged with water when the apparatus is in motion. Thus the leakage, if any, which the suction in the rear of the pipe creates is satisfied by water instead of air.

m m m. The brackets, transverse bars, and vertical slides, forming an adjustable framework.

The details of these arrangements will be readily understood by inspecting the drawing, including figs. 2 & 3 (Plate XIII.).

In the tabulated statement of experimental results (p. 261), the diameter of the tube used, the diameter of the pressure-hole, its level above the end of the tube, and the immersion of the end of the tube below the surface of the water are fully stated.

It is obvious that, under the arrangement described, the changes of pressure indicated by the rise and fall of the water in the glass tube include not only that due to the difference in the height of the column, but also that due to the small variation in the tension of the air within what has been called the "vacuum-chamber." This circumstance has to be taken account of in the interpretation of the observed results, and involves a calculation, which, however, is readily made, in terms of the ratio of the diameter of the glass tube to the capacity of the vacuum-chamber. Taking account of the dimensions of the parts, the correction is made by adding 15 per cent. to the observed change of column. This correction has been made throughout in framing the table, and the figures there given may be accepted as expressing the true pressures in terms of head of water at about the temperature of 60° Fahr.

The adaptation of what has been called the water-deck was found to be absolutely necessary after a few preliminary trials had been made without it. Indeed, as the depth to which the pressure-pipe could be immersed was of course limited, it had from the first been a question how far the pressures on the apertures would be affected by the proximity of the free surface of the water—since the natural stream-line forces, which would have existed in their completeness had the immersion been of unlimited depth, would inevitably tend to resolve themselves, to some extent, into some kind of wave-motion or surface-disturbance; and the first few preliminary trials led to the suspicion that this cause was producing effects of tangible magnitude, and to the belief that they might become very great at high speeds: a trial was therefore made at a speed of 900 feet per minute.

The effect of this speed was so remarkable as to deserve notice, if only as affording a striking exhibition of some of the forces inherent in stream-line action.

The end of the pipe was immersed 21 inches, the pipe being $1\frac{1}{2}$ inch in diameter.

Immediately in front of the pipe, and embracing its anterior surface, the water rose in a thin sheet, which was shattered on the underside of the divided disk. In the immediate rear of the pipe the exact state of the water-surface could not be very clearly discerned, because the conoidal sheet of water which shot upwards from the sides of the pipe, and was broken up by the framing of the truck, fell in such a "heavy rain" as to obscure the view; probably, however, the water-surface was opened in a deep "gash" nearly to the full depth of the tube's immersion.

The most striking phenomenon was that which appeared at a small distance sternward "in the wake."

At about 3 feet astern of the tube the "gash" had become closed by

Table of Results of Mr. Froude's *Experiments with the Apparatus described in his Memorandum.*

External diameter of pressure tube.	Diameter of pressure hole.	Distance of pressure hole from lower end of tube.	Depth of immersion of lower end of tube.	Depth of immersion of pressure hole.	"Angle of position" of "neutral point."	Pressures recorded for various "angles of position" (that is, angular distances of hole from front side of tube) at a speed of 6 feet per second. The several "angles of position" head the several columns.									
in.	in.	in.	in.	in.	°	0°	10°	20°	30°	50°	55°	70°	90°	135°	180°
* 1·42	0·05	4	16	12	37·4	·549	·506	...	...	...	...	−·496†	−·345†	...	−·368
* 1·42	0·05	4	13	9	37·4	·548	...	...	...	...	...	−·502	−·368	...	−·379
* 1·42	0·15	4	16	12	39·3	·556	·528	...	...	...	...	−·552	−·379	...	−·379
* 1·42	0·05	0·5	12·5	12	35·4	·517	...	...	...	...	...	−·770	(‡)	−·787	−·528
* 1·42	0·05	0·5	12·5	12	35·1	·506	...	...	...	...	...	...	...	...	...
1·42	0·05	12	15	3	38·0	·549	...	...	...	...	...	−·476	−·368	...	−·370
1·42	0·05	12	21	9	36·4	·546	...	...	...	...	...	−·632	−·494	...	−·620
1·42	0·05	12	15	3	38·1	·551	...	...	...	...	...	−·488	...	...	...
1·42	0·05	12	18	6	37·3	·549	...	...	...	...	...	−·569	...	...	...
1·42	0·05	4	13	9	37·6	·545	...	...	...	...	...	−·505	−·345	...	−·368
1·42	0·05	4	19	15	36·9	·552	...	...	...	...	...	−·511	−·379	...	−·414
1·42	0·05	1	16	15	35·2	·538	...	...	...	...	...	−·804	−·747	...	−·575
1·08	0·05	12	15	3	37·3	·547	...	...	...	...	...	−·551	−·414	...	−·402
1·08	0·05	12	21	9	36·1	·542	...	...	...	...	...	−·666	−·534	...	−·575§
1·08	0·05	4	13	9	38·2	·551	...	...	...	−·269	...	−·494	−·356	...	−·379
1·08	0·15	4	13	9	40·6	·547	...	...	...	−·225	...	−·517	−·391	...	−·373
1·08	0·05	1	7	6	37·3	·545	...	...	...	−·292	...	−·572	−·414	...	−·402
1·08	0·05	0·5	7	6·5	37·3	·531	...	...	...	−·296	...	−·609	−·425	...	−·437
1·08	0·15	0·5	7	6·5	39·5	·531	...	...	...	−·255	...	...	...	...	...
1·08	0·15	4	7	3	42·9	·550	·535	·434	·271	...	−·230	−·368	−·218	−·241	−·218
1·08	0·05	4	7	3	40·5	·549	...	·402	...	...	−·264	−·333	−·218	−·224	−·207
0·5	0·15	4	7	3	45·5	·549	...	...	·326	...	−·225	−·460	−·333	−·333	−·322

N.B.—The pressures are throughout given in decimals of a foot, and give the true pressure, not that actually read off the instrument. The theoretical head or pressure due to 6 feet per second is ·556 feet.

* These results were obtained before the "water-deck" was fitted.

† Really taken at $67\frac{1}{2}$° and $87\frac{1}{2}$° respectively.

‡ Less than −·800, but could not be read off, being below the index-tube.

§ Really taken at $177\frac{1}{2}$°.

the gradual meeting of the side streams which had bounded it: from this point to about 7 or 8 feet further sternwards there rose vertically a central wall of water, the crest of which, in its side elevation, had a parabolic form (as far as could be estimated by the eye), the highest part of the ridge being certainly over 2 feet above the natural water-level; its sectional form was tolerably discernible when it was looked at endways, and was not unlike that of an ordinary fountain issuing from a circular orifice; the thickness increased as the upward velocity lessened, till at the crest the water spread laterally in a kind of mushroom form, and fell in streams on either side. These streams in side view formed ragged sheets, through which the central wall of water could be seen at intervals.

The disarrangement of forces which at high speeds took so intensified a form would of course produce results of sensible magnitude at smaller speeds; but it seemed that a tolerably effective remedy would be supplied by the application of the water-deck which has been already described.

This was so arranged that the depth of its immersion could be varied within moderate limits. If too little immersed it would not sufficiently restrain the surface-disturbances, or might allow the intrusion of air. If too deeply immersed it might produce stream-line forces of its own, though its under surface was plane from end to end and truly horizontal. Eventually it was found to produce least disturbance when its underside was immersed about $\frac{7}{8}$ of an inch, and at this level it was maintained during the subsequent experiments. The area of the deck was 19 inches in length and 14 inches in width.

One valuable purpose which the deck served was to give additional steadiness to the tube. Some collateral experiments showed distinctly that the pressure in a long tube of small diameter underwent most abnormal disturbances; and though it can hardly be said with confidence that tremor would account for these, it is the only condition which suggests itself as a possibly relevant "vera causa;" and even in the experiments which are reported, there are certain discordances which may possibly be attributable to the same cause, though the tubes used were stiff and were pretty rigidly held at the deck level: the discordances or unintelligible differences were felt, not in the maximum pressure delivered on an aperture exactly facing the line of motion, but in the pressure exhibited in the experiments relative to the position of the neutral point and to the negative pressures.

In performing each experiment the aperture was set in the required direction and the apparatus clamped. The zero of the pressure-scale was brought to a convenient level according as a negative or positive pressure was to be expected. The zero was recorded; and the mean height attained by the water in the tube was also recorded when the steady speed was attained.

Partly because time did not permit the extended variation of conditions which was desired, partly because, at higher speeds, increase of tremor (or of the unknown cause of irregularity whatever it may be) was to be apprehended, the speed adopted throughout the tabulated experiments was 360 feet per minute.

After these explanations, the details of the tabulated statement must be allowed to speak for themselves. It does not, however, contain the record of the experiments with the pipe-end flush with the underside of the deck, or of those made with the hole in the stopped end of the ordinary pressure-tube, because the particulars were not readily reducible to the form of the table. The results were therefore fully stated in the prefatory matter.

The series of experiments requires extension in many directions which

are at once obvious: one of the most important of these is that which relates to the effect experienced by a pressure-tube when arranged as a log, from the stream-line disturbances which the passage of a ship's hull introduces into the relative speeds of the water surrounding the various parts of the hull.

It is hoped that this latter investigation, and perhaps all the others that are required, may be introduced as part of the series of experiments on the forms of ships which I am conducting here for the Admiralty, since the two subjects are inherently and closely related to each other. But the introduction of the experiments now reported has under present circumstances been, in effect, an interruption; and though the interruption was permitted, it has been carried to the full limits of the permission.

Incomplete as the experiments are, they tend, I fear, to confirm rather than to dissipate the difficulties which have to be overcome before the pressure-log can be accepted as supplying the greatly desired object, an independent and self-justifying measure of a ship's speed.

The inventors whose plans have been before the Committee have, I believe, felt the difficulties forcibly. Mr. Berthon* and Mr. Napier have indeed expressed their belief that it was unsurmounted, perhaps unsurmountable.

The foremost of the difficulties to be overcome is that of finding a self-justifying zero of the pressure-scale.

This, *primâ facie*, might have been supplied by either of three conditions:—

(1) The determination of the position of neutral pressure.

(2) The determination of the position of maximum negative pressure, and the ratio of this to the maximum positive pressure.

(3) The determination of the ratio of the negative pressure, in the region of tolerably uniform negative pressure in the rear of the tube, to the maximum positive pressure.

With regard to the former of these conditions, the present experiments show, I think, conclusively that the position of the neutral point is governed by conditions which it is difficult to count on with certainty; or if this difficulty be surmounted at all, it only can be by much laborious investigation: there remains the circumstance that the neutral point is placed exactly where the pressure is changing with maximum rapidity in terms of angle of position; so that any small error in taking account of the governing conditions will produce the greatest relative amount of error in the working zero from which the pressures are counted.

Thus the very elegant and instructive proposition as to the existence of this neutral point at a little over 40° from the line of motion, which Mr. Berthon discovered and determined with approximate exactness, and announced long before the promulgation of the doctrine of stream-lines had shown that such a point should exist nearly in that position, appears to involve special difficulty in its utilization as the basis of a pressure zero.

And difficulties hardly less serious in amount attach themselves to the determination of the two other conditions which have been referred to, though it is no doubt true that subsequent examination may determine with sufficient exactness the conditions which govern the relation of the negative pressure in the rear of the tube, to the positive pressure in front of it, in such a manner that the causes of uncertain variation may be excluded, and

* Mr. Berthon has since informed me that I have rather overstated his opinion on this point.

that the entire disturbance of pressure may be capable of definite interpretation.

If this can be accomplished so that in effect a working zero can be established, the only difficulty remaining to be encountered is the collateral one which arises from the motions impressed by the passage of the ship on the fluid which she displaces; this too, however, may prove not altogether intractable.

Apart from the unexpected variations in results the general character of which had been already known, the only new results which have been brought out by these experiments have been those which relate to the state of pressure at the end of the pressure-tube, whether (1) it project into the water in the usual manner, or (2) be cut off absolutely flush with the surface through which it issues.

The fact that in the former case the area of the pipe-end when stopped is covered (so to speak) with negative pressures which are of considerable amount, and which vary largely within a limited area, only serves to show that this part of the tube cannot be usefully applied to the purposes of the log.

But the fact that (contrary, I own, to my previous belief), in the latter case, the pressure seems to be almost absolutely neutral, whether the end of the tube be stopped with a perforated plane or be wholly open, suggests the hope that here also might be found a tolerably sound basis for a working zero of pressure. Doubtless the use of it would be exposed to one important objection—namely, that if a barnacle were to attach itself to the surface anywhere near the aperture, especially in front of it, the truthfulness of the zero would be destroyed; it is possible, too, that some causes of error might be found to exist in the "drag" of the eddies in the belt of water disturbed by the friction of the ship's surface. Nevertheless the idea that a trustworthy zero may be obtained on this basis, suggests itself as one deserving of consideration and inquiry.

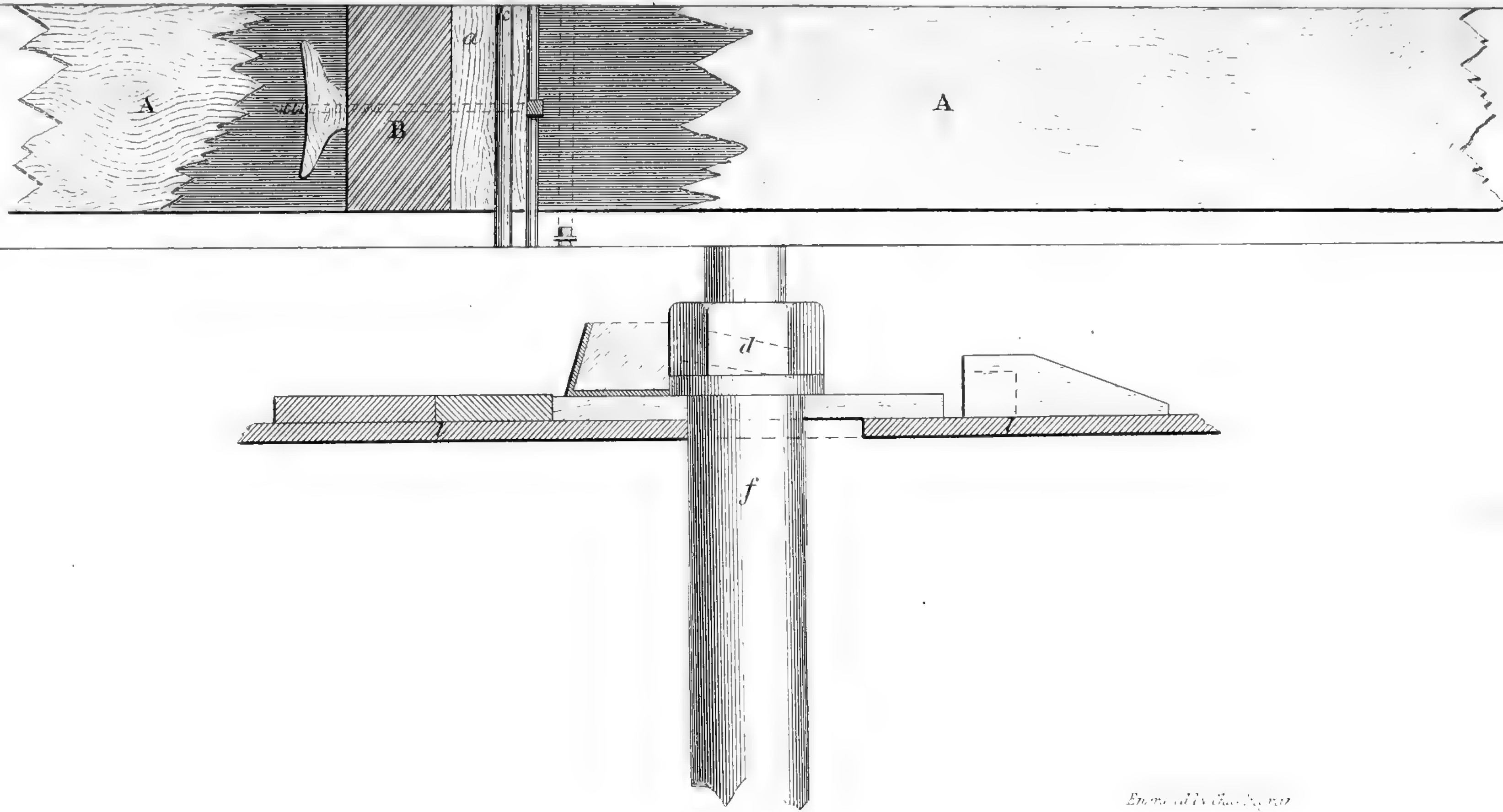
Nothing in these experiments, however, tends at all to disparage the value of an instrument based on the principle which has been investigated, if the instrument be regarded as one the scale of which has to be interpreted by special experiment after it has been fitted to the ship in which its indications are to be made use of; and although in some respects its value would have been considerably greater if its scale could have been regarded as self-interpreting and self-justifying, yet, even under the practical limitation which has been referred to, the instrument, if well organized, must be regarded as possessing the highest practical usefulness.

W. FROUDE.

Report of the Committee, consisting of the Rev. H. F. BARNES, H. E. DRESSER (Secretary), T. HARLAND, J. E. HARTING, Professor NEWTON, *and the* Rev. Canon TRISTRAM, *appointed for the purpose of inquiring into the possibility of establishing a "Close Time" for the protection of indigenous animals.*

THE Committee reappointed at Bradford to continue the investigation on the desirability of establishing a "Close Time" for the preservation of indigenous animals, beg leave to report as follows:—

1. The Report of the Select Committee, appointed in 1873 by the House of Commons to consider the subject of the Protection of Wild Birds, which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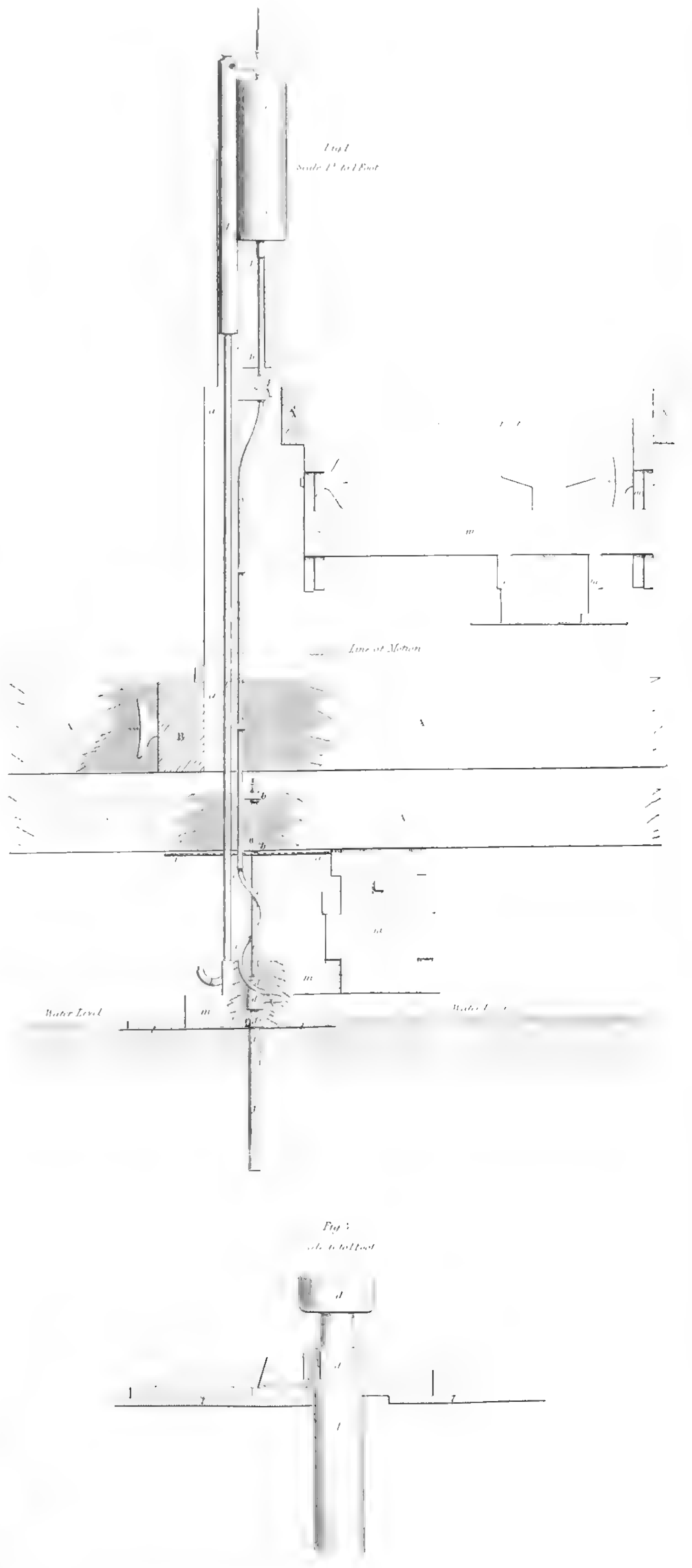

Fig 1
Line of Motion
Water Level

Speed of Ships.

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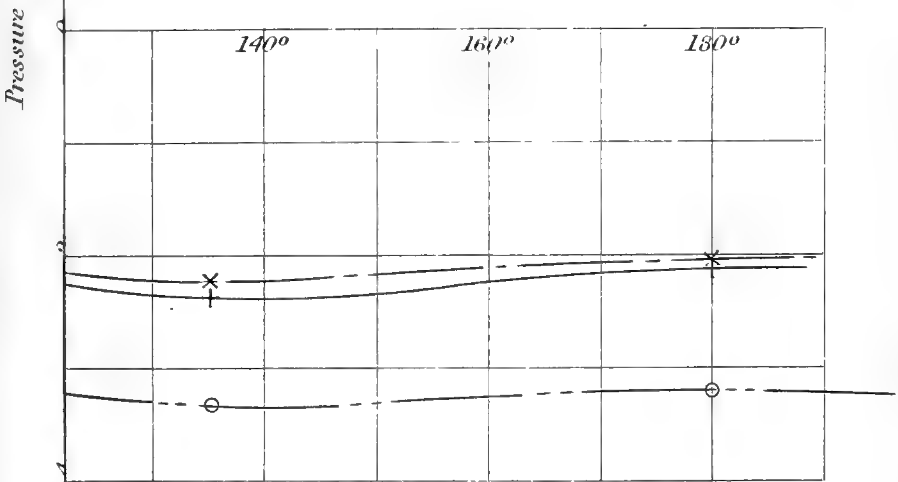


Engraved by Chas. Ingram.

British Association Committee on Instruments for Measuring the Speed of Ships

Mr Froude's experiments with Pressure Log

Graphic exposition under three conditions, of preliminary experiments to determine the pressure according to the angle of position of the pressure hole

The three strong lines with distinctive dots corresponding with the three conditions as stated below show the pressures as ordinates with the angles of position as abscissae.
The three faint lines with similar distinctive dots show for comparison those curves each having the same maximum ordinate and the same zero [illegible]
The spots or marks + × ○ show the results of individual experiments.

had not been published when your Committee agreed to their last Report, appeared shortly afterwards, and contained recommendations almost entirely identical with the anticipations of your Committee.

2. These recommendations were so fully considered by your Committee in their last Report, that they think it unnecessary to refer again to the subject beyond expressing their regret at finding, from the printed and published evidence taken by the Select Committee, that its recommendations were not at all in accordance with such parts of that evidence as your Committee deem the most trustworthy and valuable.

3. The delay in the meeting of Parliament, occasioned by the General Election and change of Ministry, made your Committee believe that it would be inexpedient for them to attempt any amendment of the 'Wild-Birds Protection Act' during the late Session.

4. In the House of Lords the Earl De la Warr introduced a Bill intituled "An Act for the more effectual protection of Wild Birds during the Breeding-Season," the principal feature of which was to render penal the taking of certain birds' eggs. This Bill was not based on any of the recommendations of the Select Committee of the House of Commons (1873), and still less on any suggestions which have ever proceeded from your Committee.

5. Lord De la Warr's Bill was withdrawn; and your Committee take this opportunity of declaring their belief that the practice of birds'-nesting is and has been so much followed in England that no Act of Parliament, except one of the most severe character, could stop it; while any enactment of that kind would, by filling the gaols with boys (often of a tender age), excite a strong and universal feeling of hostility against all measures for the protection of indigenous animals, even among many of those who are at present favourably disposed to it.

6. Your Committee believe that the effect of birds'-nesting on such kinds of birds as are known to be diminishing in numbers is altogether inappreciable, while its effect on those whose numbers are not decreasing may be safely disregarded, and consequently that there is no need of any legislation interfering with the practice. They again repeat their conviction that the only practicable mode of checking the diminution of such birds as have been proved to be decreasing, is the effectual protection of the adults from destruction during the breeding-season.

7. Your Committee find that while the Sea-Birds Preservation Act continues to work successfully, being not only popular but also effective in its operation, the Wild-Birds Protection Act has done little if any thing towards attaining the objects for which it was passed, and in various quarters still gives considerable discontent.

8. Your Committee have once more to point out, as they have done in former Reports, that the birds commonly known as "Wild Fowl" are subject to very great persecution through the inadequacy of the present law to protect them, that they are rapidly decreasing in number, and that they are not only perfectly innocuous but of great value as food. Consequently your Committee trust that the efforts they hope to make in behalf of "Wild Fowl" in the next Session of Parliament will obtain a very general support.

9. Representations as to the inordinate slaughter of Seals which takes place every spring in the North-Atlantic Ocean have been made to some Members of your Committee. There can be no doubt that such slaughter carried on at that season, and with increasing activity, will soon bring these animals to the verge of extermination, as has been the case in so many parts of the world; and since their destruction will affect a very large trade, their

proper protection seems to be a subject not at all unworthy of the consideration of Her Majesty's Government. Your Committee, however, are of opinion that the subject is one lying beyond the powers entrusted to them, since the Seals of the North Atlantic can in no sense be termed "Indigenous Animals," and accordingly refrain from offering any other remark upon it.

10. Your Committee respectfully request their reappointment.

Report of the Committee, consisting of Lord HOUGHTON, Professor THOROLD ROGERS, W. NEWMARCH, Professor FAWCETT, *M.P.*, JACOB BEHRENS, F. P. FELLOWS, R. H. INGLIS PALGRAVE, ARCHIBALD HAMILTON, *and* SAMUEL BROWN, Professor LEONE LEVI (Secretary), *appointed to inquire into the Economic Effects of Combinations of Labourers and Capitalists, and into the Laws of Economic Science bearing on the principles on which they are founded.*

YOUR Committee, appointed to inquire into the economic effects of combinations of labourers or capitalists, and into the laws of economic science bearing on the principles on which such combinations are founded, beg to report as follows:—

Public attention has for a considerable time past been directed to the extensive prevalence of combinations both among labourers and capitalists in nearly all the principal trades and industries, to the frequent conflicts which have occurred between employers and employed, and the strikes and lock-outs which have followed. And already several public inquiries have been instituted on the subject in its general bearings. In 1854 a Conference on strikes and lock-outs was held at the Society of Arts, when the first point of discussion was "Combinations—are they objectionable, whether set on foot by employers or employed, as a means of influencing the Value of Labour?" In 1859, the Council of the Social Science Association appointed a Committee for the purpose of reporting on the objects and constitution of trade-societies, with their effects upon wages and upon the industry and commerce of the country; and their report is extremely valuable for the vast amount of information it conveys, as well as for the lessons it contains. In 1866 Her Majesty's Government appointed a Royal Commission to inquire into and report on the organization and rules of trade-unions and other associations, whether of workmen or employers, and to inquire into and report on the effects produced by such trade-unions and associations on the workmen and employers respectively, and on the relations between workmen and employers, and on the trade and industry of the country. These reports, together with the extensive literature which has accumulated on the subject, furnish sufficient materials for arriving at a sound judgment on the questions submitted for consideration; nevertheless it is too evident that the economic bearings of the question at issue are as yet but insufficiently appreciated, especially by the parties most interested in the question. It were, indeed, much to be desired that the relations of capital and labour were put on a more satisfactory footing than they now appear to be placed; and your Committee trust that they may render some practical service to the contending parties, if they are able to test the claims urged by either employers or employed by reference to the sound principles of political economy. Generally speaking, the objects of trade-unions are

twofold. In their character as *friendly societies* they afford relief to the members of the unions when incapacitated from work by accidents or sickness, and they provide superannuation allowances for members when incapacitated by old age, as well as a sum for the funeral expenses of the members or their wives. As *workmen's protection societies*, trade-unions endeavour to promote the interest of workmen in matters of wages and hours of labour, to bring about a more equal division of work among the members of the union, and, if needful, to create a monopoly of labour with its attendant powers to command a higher rate of wages. The means used for such purposes are ordinarily the enforcement of rules limiting the number of apprentices to be allowed in a trade, excluding from work, as far as possible, workmen not belonging to the union, and prohibiting the employment of boys to do work which ought to be done by men. Whilst the employed have thus organized themselves into trade-unions, the employers have likewise resorted to concerted action in many forms.

Often do they combine in order to regulate the prices of sale of any commodity, as the ironmasters are wont to do. Often do they combine in getting privileges for themselves; but the most signal instance of recent combinations among employers is the constitution of a specific society for the protection of their interests.

The National Federation of Associated Employers of Labour, recently organized in Manchester, is a defensive organization by the employers of labour to resist the designs of trade-unions, so far as they are hostile to the interests of employers, the freedom of non-unionist operatives, and the well-being of the community.

Although, however, the general object of such combinations, whether of capitalists or labourers, is well known, both from the written rules which bind them together and from the action they have taken from time to time, your Committee have deemed it desirable to ascertain, by personal contact with some representative men from both classes, whether they do now stand by the rules of their unions, and how far they are prepared to defend them. For this purpose your Committee resolved to hold a consultative private conference of employers and employed, not exceeding six or seven on each side, in the presence of the members of the Committee, and under the presidency of Lord Houghton, for the purpose of discussing the questions involved in the resolution of the British Association, and with a view of reporting thereon to the same. The conference was accordingly held on the 19th of May last in the rooms of the British Association, 22 Albemarle Street, when the questions more especially discussed were:—

1st. What determines the minimum rate of wages?

2nd. Can that minimum rate be uniform in any trade? and can that uniformity be enforced?

3rd. Is combination capable of affecting the rate of wages, whether in favour of employers or employed?

4th. Can an artificial restriction of labour or of capital be economically right or beneficial under any circumstances?

And for the discussion of these questions your Committee had the advantage of bringing together a deputation from the National Federation of Associated Employers of Labour, including Messrs. R. R. Jackson, M. A. Brown, H. R. Greg, Joseph Simpson, J. A. Marshall, R. Hannen, and Henry Whitworth. As representing labour:—Messrs. Henry Broadhurst, Daniel Guile, George Howell, Lloyd Jones, George Potter, and Robert Newton—Mr. Macdonald, M.P., and Mr. Burt, M.P., having been prevented from attending, And on the part of your Committee there were Lord Houghton, Professor

Rogers, Mr. Samuel Brown, Mr. A. Hamilton, Mr. Frank Fellows, and Professor Leone Levi.

The discussion at the conference was carried on in the most friendly spirit, and, in the opinion of your Committee, with manifest utility towards the elucidation of the questions at issue. From the employers your Committee have, moreover, received valuable written answers to their inquiries; whilst the 'Beehive,' the principal organ of the employed, said of the Conference, "The case was stated with great frankness, and the attack and defence was carried on in perfect good humour for three hours; and whether any conviction on either side was altered or not, it was proved very distinctly that such meetings, if held more frequently, could not fail to beget a clearer view of the questions in dispute on both sides, and a stronger disposition than now exists to arrange differences in a friendly and peaceable spirit. We do not know whether it would be within the province of the Committee of the British Association to call a series of meetings composed of men from each side competent to deal with the question in dispute, where they might be taken *seriatim* and thoroughly inquired into and discussed. A series of such meetings would prepare the ground for some practical work, such as would bring into reconcilement the reasonable and fair men and lovers of peace on both sides." Your Committee have not been able to exhaust the inquiry on the points of dispute between employers and employed, nor to enter into any suggestion of a remedial character on which the opinion both of employers and employed would be extremely useful. And under such circumstances your Committee have decided not to make a final report on the present occasion, but to recommend the reappointment of the Committee of the same members as it stands, with power to add to their number, with instructions to renew the conferences already inaugurated between employers and employed, and to report on the general question; and your Committee recommend that another grant of £25 be made for the purpose of such inquiries.

Preliminary Report of the Committee, consisting of J. GWYN JEFFREYS, *F.R.S.*, G. S. BRADY, D. ROBERTSON, *and* H. B. BRADY, *F.R.S., on Dredging on the Coasts of Durham and North Yorkshire. Drawn up by* DAVID ROBERTSON *and* GEORGE STEWARDSON BRADY.

THE dredging off the coasts of Durham and North Yorkshire, provided for by a grant from the British Association last year, was carried out during the week beginning on the 13th of July. A suitable steam-vessel was engaged, and being on the whole favoured by the weather, we dredged every day until the 18th inclusive. During two days the Rev. A. M. Norman accompanied us; we were indebted to him for valuable assistance in naming some of our specimens, as well as for kindly undertaking to report on some sections of the work.

On two days out of the six the sea was too rough to allow of the dredges being worked very successfully, and one dredge was unfortunately lost by getting fast on hard ground while a very strong tide was running; but with these exceptions the work was carried out satisfactorily. The dredging ranged from near Tynemouth on the north, to Scarborough on the south, the water varying in depth from 20 to 45 fathoms, the greater portion of the time being devoted to a belt (known to fishermen as the inner "fishing bank") lying from 4 to 8 miles from the shore. One day, however, was spent

at the greater distance of 30 to 40 miles from shore, and another day at a distance of about 17 miles.

Time has not allowed of any thing more than safely to preserve and arrange our captures. On a future occasion we hope to give a full account of the results obtained.

Report on Observations of Luminous Meteors during the year 1873–74, *by a Committee consisting of* James Glaisher, *F.R.S., of the Royal Observatory, Greenwich,* R. P. Greg, *F.G.S., F.R.A.S.,* C. Brooke, *F.R.S.,* Prof. G. Forbes, *F.R.S.E., and* Prof. A. S. Herschel, *F.R.A.S.*

(Plates XV. & XVI.)

The appearances of meteors noticed in published journals, and otherwise ascertained by the Committee during the past year, include some striking examples of such remarkable exhibitions discussed and investigated very ably by astronomers, as well as of others passing almost unobserved excepting by accidental gazers. A few such large meteors were doubly observed in England; some have been visible in the daytime, while many other large and small fireballs have been described to the Committee, of which it is to be regretted that notices have hitherto only reached them from single observers. The months in which these phenomena have been most abundant were September, December, and January last, April, June, and again quite recently the last few days of July and beginning of August in this year. The Report contains descriptions of the brightest of these meteors, and an account of Prof. Galle's calculations and inquiries regarding the real course of a large meteor which passed over Austria on the 17th of June, 1873, with the probable path that he assigns to it. With the exception of those of Khairpur, India, in September, and Vidin, Turkey, in May last, no occurrence of a fall of aërolites, as far as the Committee is aware, has taken place during the past year.

The annual star-showers have been watched for with the usual attention of observers in correspondence with the Committee, and the results of their combined observations are described, with accounts of some other occasional star-showers, at some length in the descriptive part of the Report. Although little important information was thus added this year to our present knowledge of the well-known star-showers of January, April, and October, and the cometary meteor-streams of November 14 and 27, connected with Temple's and with Biela's comet (all of which, in spite of very favourable weather for their observation, were this year of not very conspicuous appearance), yet the fluctuating intensities of these showers at their successive periodic dates is an important element to record; and in the case of the star-showers of August 10th and December 12th of the past year, the watch was at least attended with more positive success. Duplicate observations of meteors were obtained in them, and the general centre of divergence of each of these two meteor-currents was pretty exactly ascertained. Bright meteors were more frequent on each of these two nights than is at all usual in ordinary exhibitions of those showers. It will be found among these observations that the return of Biela's meteor-shower on the 27th of November last disappointed expectation; and the small extent and rapid departure of that meteor-cloud from the earth's neighbourhood is clearly shown by its visibility

as a star-shower only for a single year. The duplicate observations described in former Reports have been reduced at the request of the Committee by Mr. T. H. Waller, whose report of these calculations is added, and whose conclusions of their real heights and velocities are without doubt very accurate and complete.

The publication of Captain Tupman's observations of shooting-stars in the Mediterranean during the years 1869–71, with the list of radiant-points obtained from them, shown on a pair of convenient charts, or plates accompanying them, by Captain Tupman (recommended for immediate consideration of the Committee during the last two years), is now brought to a close; and the catalogue and charts have been sent to astronomers and correspondents of the Committee in England, abroad, and in America; and discussions of them in foreign scientific journals have appeared, showing the important light in which the appearance of this valuable new meteor-catalogue has been regarded. Its principal part, the comparative catalogue of his meteor-showers with those of other observers, and the charts on which they are projected, are presented in this Report, with Dr. Schmidt's similar catalogue (the remaining two principal meteor-shower lists, of which no account has yet appeared at full length in these Reports), thus placing before readers of recent volumes of these Reports all the material contributions to this branch of meteoric astronomy that have yet been made. They are summed up in a very concise catalogue contained in this Report by Mr. Greg, who has selected (to corroborate such observations already published in his former lists) the greater part of Dr. Schmidt's and Captain Tupman's observations, and has included them with his own former collections, thus forming a very extended catalogue founded on all the similar work of his contemporaries, and omitting but few general meteor-showers from his copious list, observed chiefly by Dr. Neumayer in the southern hemisphere.

Following the method of Dr. Weiss, of calculating the radiant-points of those comets of early and recent times whose orbits are believed to pass near the earth, a list of such comets for both the northern and southern hemispheres is annexed to Mr. Greg's catalogue, and the cases where they corroborate each other are pointed out. Many important and well-known comets are found to have modern meteor-showers as their present representatives, as would perhaps be still more apparent if more reliable data of their orbits could be used; but the numerous coincidences are yet striking enough and sufficiently exact to make the further cultivation of cometary astronomy by the help of star-shower observations perhaps within the easy reach of ordinary watchers, who will continue for that end to delineate meteor-flights observed on fine nights among the well-surveyed fields of the fixed stars and their constellations.

APPENDIX.

I. Meteors Doubly Observed.

Detonating fireball of June 17th, 1873; Hungary, Austria, and Bohemia. Calculation of the meteor's real path by Dr. J. G. Galle*. Although, from its great size and some other unusual circumstances of its appearance, the following description of this large meteor, extracted from the published account of it by Dr. Galle, might properly be presented in the next Appendix

* Astronomische Nachrichten, Nos. 1989–90, vol. lxxxiii. p. 321 *et seq.*, March 1874. Published also at somewhat greater length, omitting the mathematical formulæ, in a communication by Dr. Galle, presented to the Meteorologische Section der schles. Gesellsch. für vaterl. Cultur at their meeting on December 17, 1873. See Jahresberichte der schlesischen Gesellschaft, 1873–74.

on Large Meteors and Aërolites, yet the careful investigation of its real path and of its orbit round the sun made by Dr. Galle and by other German astronomers, from the many exact observations that were obtained in their neighbourhood of its appearance, render its description in the first place of this Appendix especially appropriate. The meteor was seen in full twilight at 8^h 46^m P.M., Breslau mean time, about half an hour after sunset, skirting the S.W. horizon at no great altitude at Breslau, and proceeding with very little downward inclination westwards: by means of a meteoroscope Dr. Galle, who saw the meteor at Breslau, obtained the exact places of two points on the luminous streak which it left visible in the sky for more than a quarter of an hour after the disappearance of the nucleus; and an assistant at the Observatory, who also saw it, accustomed to observe the time of flight of ordinary shooting-stars, counted 9 seconds as the duration of the meteor's flight from its first appearance until the time of its explosion and extinction. Dr. Weiss at Vienna, and Dr. Hornstein at Prague, communicated to Dr. Galle equally valuable observations. In the pages of the 'Astronomische Nachrichten' (No. 1955) for September 1873, an exact calculation of the meteor's real path by Prof. v. Niessl, of Brünn, from ten or twelve excellent descriptions of its course at places in Moravia and Bohemia (immediately beneath or on the west side of the meteor's course), had appeared. Dr. Galle observes that but for the unusual astronomical exactness of some accounts, the particulars of which had reached him from Silesia and places chiefly east of the meteor's course, it would have been superfluous to recalculate the meteor's course by the new rigorous method which he proposed from all the observed data, so perfectly did the observations collected, and the calculations made from them by Prof. v. Niessl, establish the general character of the meteor's course. Complete mathematical formulæ are given by Dr. Galle, showing how, independent weights having first been assigned to the positions given in the different observers' descriptions, the whole can be combined together so as to furnish without very laborious calculation the most probable path, and the amount of probable error of the determination of the meteor's real course. Apart from these calculations, Dr. Galle also visited the locality in Oberlausitz, between Saxony and Bohemia, over which the meteor appears to have exploded, and ascertained the correctness of this supposition from the accounts of many observers who saw the meteor burst there directly overhead. It has been conjectured by Dr. Galle, in his investigation of the real path of the fireball and other interesting questions relating to the shower of stones at Pultusk, near Warsaw, on the 30th of January, 1868 (see the volume of these Reports for 1868, p. 388), that the so-called bursting into fragments, or "explosion," and the accompanying loud reports seen and heard at the disappearance of large detonating or aërolitic fireballs, arise from the expansion of compressed air before the meteorites at the moment when their once planetary velocity is so arrested and diminished by resistance as to allow sound-waves to start from them in all directions; at that time the intense illumination ceases and the largest fragments only pursue their onward course, also shortly to become extinguished and to produce louder and more violent reports than the smaller stones, from their greater surface and exposure to compression of the air. Thus as each atom, grain, or fragment of a stone-swarm, when it first enters the atmosphere, is arrested in its flight, it yields up its light and planetary speed, and following as a dull spark in the meteor's train, it marks the first moment of its fall towards the earth under the mere influence of gravity alone by a more or less audible explosion. To observers near the point of disappearance of such large meteors, the loudest explosions arising from the largest aërolites which

penetrate furthest are heard first like one or several cannon-shots, probably indicating if there is only one or if there are more than one such large aërolites included in the swarm. The smaller more distant detonations are heard afterwards following the principal shots as a confused rattling sound, generally compared to musketry or to the rattling and rolling sound of a near peal of thunder. Such is shown both by telescopic examinations and naked-eye observations of the structure of many large fireballs, as well as by the frequent occurrence of such showers of stones as those of Pultusk, Stannern, or L'Aigle, where the largest stones are found leading the fall and the whole area scattered over lies almost vertically below the point of explosion or disappearance of the meteor. Such was apparently the condition at Pultusk; and the height of $20\frac{1}{2}$ English statute miles above the earth's surface at which the present meteor disappeared, resembling exactly that of the point of disappearance of the Pultusk fireball, coupled with the fact that few or no distinct explosions but, as generally described, a prolonged rattling sound as of many small reports, lasting for nearly a minute, was produced by the bursting of this meteor, Dr. Galle was prepared to hear in his inquiries on the spot of some small aërolitic fragments having been discovered near the place which he ascertained to be under the meteor's point of disappearance; but the ground was thickly clothed with grass and forests; the hour of the evening when the meteor appeared was already late, and the chance of their observation or recovery, if any fell, was on these accounts extremely small*. It is remarkable that perfectly authentic statements were received of the deposition, soon after, or about the time of, the meteor's explosion over Zittau and its neighbourhood, of a mass of melted and burning sulphur the size of a man's fist, on the roadway of a village, Proschwitz, about 4 miles south of Reichenberg, where the meteor exploded nearly in the zenith. It was stamped out by a crowd of the villagers, who could give no other explanation of its appearance on the spot than that it had proceeded from the meteor; on examination at Breslau some remnants of the substance proved to be pure sulphur. With regard to the calculated course, the meteor must, however, have passed quite 12 or 14 miles south-westwards from the place where this event is said to have occurred; and its questionable connexion with the fireball is accordingly rendered very doubtful from the great distance of the locality from immediately below the meteor's course. In Chladni's work on Fiery Meteors and Stonefalls, only one similar instance is recorded, from ancient chronicles, where burning sulphur fell at Magdeburg, of the size of a man's fist, on the castle-roof at Loburg, 18 miles from Magdeburg, in June of the year 1642. The fact of this large fireball having deposited any stony or other aërolitic matter cannot therefore yet be regarded as decidedly established.

The most remarkable circumstance connected with this meteor's real course, both as calculated by Prof. v. Niessl and by Dr. Galle, is that the speed of its motion, combined with the calculated direction of its flight, belong to an orbit round the sun which was decidedly hyperbolic. The principal alteration of the real course found by Prof. v. Niessl, that was introduced by the observations in Silesia, West Prussia, and Austria collected by Dr. Galle, depended upon an excellent description of the meteor's first appearance at Rybnik and Ratibor, two towns in Upper Silesia, as well as on equally certain positions obtained at the observatory and in the town of

* Some accounts of a brownish dust having been seen falling, and of a deposit of fine yellow sand having been collected in its descent from the air, are contained in the original descriptions; but the evidence of these occurrences appears to have been too slight and indistinct to allow them to be certainly connected with the meteor.

Breslau in the same province. At the former places the meteor first appeared to emerge and separate itself from the disk of the planet Mars (then southing, at no great altitude), and to pursue its way westwards, gradually descending towards the horizon, where it disappeared behind a cloud. Dr. Sage, who noted this appearance of the meteor at Rÿbnik, was looking attentively at the planet Mars when he thus saw the meteor apparently issue from it, and the planet appear as if it was breaking up and dividing into two parts. After a first estimation, roughly stated at 20 seconds, Dr. Sage considered that the time occupied by the meteor's flight until it disappeared was really not more than ten or twelve seconds. The observers at Ratibor, not far from Rybnik, were equally positive of the meteor's first appearance "as if issuing from the red star in the south;" and their average estimate of the time of flight was reckoned to be $15\frac{3}{4}$ seconds; one observer, however, especially able to judge correctly of the duration, would not admit that the meteor occupied more than ten seconds in its flight. The time of flight recorded by the assistant at the Breslau Observatory was, as above mentioned, nine seconds for the whole period of the meteor's course. The point of disappearance of this meteor being known with great exactness, and the observations of the earlier part of its flight being unusually accurate, the visible track along which it shot over Hungary, Austria, Moravia, and Bohemia to the mountain confines of the latter state with Saxony, is calculated with very small probable errors by Dr. Galle.

Point of first appearance.			Point of disappearance.			Length of Path in B. S. miles.	Velocity in B. S. miles per second.	Most probable apparent position of the Radiant-point.			
Height in B. S. miles.	Long. E. from Greenwich.	North Latitude.	Height in B. S. miles.	Long. E. from Greenwich.	North Latitude.			Azimuth E. from S.	Altitude.	R.A.	Declination.
101·3	17° 16′ *	47° 30′	20·5	14° 20′ *	50° 55′	285	28·5 (a) 18·4 (b)	30° 35′	14° 32′	246° 42′	−19° 19′
70 or 80 miles S.W. from Vienna, and a few miles south of Raab in Hungary.			Near the village Gross-schönau, in Saxony, and the peaks of the Lausitzer Gebirg, between Saxony and Bohemia.					The same corrected for zenithal attraction.		247° 10′ 247° 56′	−20° 35′ (a) −22° 31′ (b)

The meteor appears from the calculation to have had an unusually long path, and to have accomplished it with very considerable meteoric speed. The velocity of $28\frac{1}{2}$ miles per second (a) is obtained if the three most certain measurements of its time of flight at Breslau, Rybnik, and Ratibor, all fixing it at very nearly ten seconds, are regarded as quite free from doubt, and as requiring no material corrections. The second calculated velocity of 18·4 miles per second (b) is obtained by adopting the average between the first and second estimates of the meteor's duration (20 seconds and 10 or 12, say 11 seconds—average 15·5 seconds) by Dr. Sage at Rybnik, and the equally general average of the ten observers' accounts (pupils in the school at Ratibor), who were asked there by Dr. Reimann to state their recollections of its duration by counting seconds with a seconds' clock. The average of these ten estimates (including the very positive minimum one of 10 seconds referred to above) was 15·7 seconds. A duration for the whole of the

* The geographical longitudes (E. from Greenwich) are taken from those of Dr. Galle's paper (referred to Ferro Isle as the starting-point) by subtracting 18° (about, Ferro Isle in the Azores, west from Greenwich) from the geographical east longitudes given by Dr. Galle.

meteor's visible flight of 15·5 seconds, from these accounts, gives the diminished meteor-speed marked (*b*) in the above Table; no reason for further extending the possible time of the meteor's flight is in any way suggested by the scattered examples of less complete observations of its whole course and duration that appear among the accounts received by Dr. Galle from many other stations.

Along this long track of nearly 300 miles the meteor increased gradually in size as it advanced, soon growing to the dimensions of a fireball of the largest class, which it maintained until it disappeared. The nucleus was pear-shaped, tapering to a tail of red sparks, several degrees in length, following the head. Some described the nucleus as triple, consisting of three fireballs travelling together; others saw jets of flame, accompanied by detached fragments, projected occasionally, giving the meteor the appearance of having a serpentine or wavy course. The prevailing colour of the meteor's light was white or yellowish; but in front projecting tongues of red flame, and sparks like those emitted from burning iron, gave the light in the forward half of the nucleus a reddish cast, only the middle of the head or body of the meteor being white or yellow. The following part of the head and some parts of the tail that shone brightest were distinctly green. The parts into which the meteor separated in bursting were numerous according to some of the descriptions—" not descending vertically, but as if projected forwards." Two or three of them appear to have been somewhat larger than the rest. A writer at Schreiberhau (Silesia ?) states that before reaching the horizon the fireball divided itself into three smaller globes equally bright-coloured with the first, which together travelled onwards in the same direction and then disappeared. The rocket-like tail of red sparks exhibited by the meteor faded away quickly, following the head; but in about the last quarter of its visible path a bright white very persistent light streak was left by the meteor on its track. It was at first straight, brightest, according to some observers, at the edges, as if hollow and cylindrical; it speedily, however, became curved and zigzag, and separated itself into shining clouds, whose bright white was visible in the sky for nearly half an hour. The time of the meteor's appearance being at about a quarter before nine, and the time when the sun set below the horizon of the meteor's point of explosion over Zittau, as found by Dr. Galle, having been only at a quarter after nine o'clock, it follows that the meteor-streak was exposed throughout the time of its visibility to the direct rays of the setting sun, and the brightness of its white light as long as it could be traced on the darkening background of the evening sky is thus accounted for. All the higher masses of the light streak had at the latter time quite dissolved away, and the utmost period of visibility of its knots and wisps as a distinguishable vapour does not appear to have exceeded half an hour. Dr. Galle calculates that it extended from a height of about 37 miles at its commencement to a height of about 20 miles, the point of explosion of the fireball; with a real length, when first deposited, of about 69 miles, and a real diameter, taking that of the fireball (as seen by observers 40 or 50 miles from its path, about one third the apparent diameter of the moon) as its least width, of not less than 230 yards. Its substance Dr. Galle considers to have been either dust or volumes of still more finely divided particles of smoke. Another question of great physical interest discussed in this paper is that of the time taken by the sounds of the reports to reach observers, and the distances to which they were heard round the point of explosion of the fireball. From the least of the time-intervals (about 1^{m} 39^{s} at Grossschönau) to the greatest calculated (at Neukirch, 4^{m} 35^{s})

answering to distances of $20\frac{1}{2}$ and 57 miles respectively from the meteor's bursting-place, the observations at about twenty stations are on the whole in perfect accordance with the supposition that the detonations and audible reports of the meteor's explosion all proceeded from the same point as that of the termination of the meteor's course. If four exceptionally discordant accounts are retained in the average, it appears as the result that the average calculated interval of 2^m 12^s for the whole list of stations is exceeded by the average of the observations themselves by 18 seconds, or by about 10 per cent. of the real value; this would easily be accounted for by the long duration (in some cases about 1^m) of the thunder-like echoes of the sound, to develop and prolong which mountainous localities would be particularly favourable: but if these four very discordant observations (all near the end point of the meteor's course) are omitted, the remaining seventeen observations exhibit no such retardation, and the average observed time-interval is identical with that found by calculation of the observers' distances from the end point of the meteor's course.

The most important conclusion established by Dr. Galle's calculations is one which Prof. v. Niessl had already demonstrated independently, that the orbit of the meteor-mass composing this fireball round the sun was neither an ellipse nor a parabola, but an hyperbola. On entering into collision with the earth's atmosphere and traversing its outer layers as shooting-stars and fireballs, meteor grains and masses present different directions of motion from those which they may be shown, by a proper treatment of the observations, to have had originally in their orbits. The causes of this difference are of various kinds, some evident and considerable, and others for the most part insensible in their effects; but tables have been given by Professor Schiaparelli for obtaining a meteor's real radiant-point in its orbit from that presented by observers' descriptions of its apparent or atmospheric path, whenever the latter is known exactly, and when the meteor's velocity is also considered to be certainly determined. In such cases every influencing circumstance can be allowed for, whether it is the earth's own rapid motion in its orbit, and its far less rapid rotation (especially in moderately high latitudes) about its axis, making the meteor's motion as observed only relative to the earth's centre (or surface when extreme accuracy is desired) instead of to the sun and fixed stars, to whose sphere alone, before its collision with the earth, the cosmical path of the meteorite properly belongs; or whether it be the earth's attraction causing the meteor to dip or descend more steeply as it approaches, and at last plunges obliquely into the atmospheric ocean. As a rifle-bullet fired horizontally over a level plain will strike it more and more perpendicularly the less the force of the charge and the speed of the projectile is made, so Prof. Schiaparelli shows that by the accumulated attraction of the earth upon it (until it enters the atmosphere and is finally arrested) an ordinary meteorite* overtaking the earth with the least possible relative speed that it can have, and grazing the earth's atmosphere horizontally at last, will have its apparent radiant-point raised 17° by "zenithal attraction," which is the name by which he has distinguished this correction. If the same meteorite moved from the opposite direction, meeting the earth instead of overtaking it, and at last grazing the atmosphere horizontally, the zenithal attraction of its apparent radiant-point would be less than half a degree, or about 0° 20′. The actual speeds of these two meteors' flights through the

* Meteoric bodies with hyperbolic or nearly circular paths (if such exist) are here excepted, and only those are considered, forming probably far the most numerous class, whose orbits are parabolas or very long ellipses.

atmosphere are about 10 miles and 44½ miles per second; and between these, as well as also according to trustworthy observations below and above these values, real velocities of aërolites, bolides, and shooting-stars have been recorded. The amount of zenithal attraction depends also on the altitude of the apparent radiant-point—meteors that descend almost perpendicularly having undergone much less deflection from their course than those which reach the atmosphere from low radiant-points, and which appear to enter it at last very obliquely. Considering these various conditions, Dr. Galle obtains two new positions "corrected for zenithal attraction" of the large meteor's observed radiant-point, differing most from its original place in the case (*b*) in the Table corresponding to the case where the least admissible value of the real velocity is assumed; and proceeding thence to construct separately from each of these adopted data the meteor's orbit round the sun, he finds it to be in each case an hyperbola of greater or less eccentricity, and that to make it a parabola the meteor's time of flight would have to be reckoned as about 17 seconds. Several observations of the duration, besides those already mentioned, collected together, show that in only one instance out of twenty-two (at Bernstadt) an observer recorded the duration of the meteor's flight as exceeding 10 seconds (12–15 seconds); and that by the great mass of the observers the time of the meteor's flight was estimated as between four or five and ten seconds, making the hyperbolic character of the meteor's orbit even more strongly probable than before. The following are the hyperbolic elements of the two orbits found by Dr. Galle, to which are added the hyperbolic elements (as above referred to in these Reports), also calculated by Dr. Galle, of the aërolitic fireball of Pultusk.

	a. Velocity 28·5 miles per second. P. p. 1873, July $11^{d}\cdot66$, Berl. M. T.	*b.* Velocity 18·4 miles per second. 1873, July $19^{d}\cdot76$, Berl. M. T.	Hyperbolic orbit of the Pultusk meteorites (*sup. cit.*). 1868, Jan. $28^{d}\cdot5$, Berl. M. T.
π.	328° 21′	328° 41′	116°
☊.	86 36	266 36*	310
i.	1 14	0 27	6
q.	0·6394 (perihelion distance)	0·7140	0·6935
a.	0·4637 (½ axis major)	0·2632	0·7547
e.	2·379 (eccentricity)	1·271	2·277
	motion direct.	motion direct.	motion direct.

The orbit is in each case nearly in the ecliptic plane, overtaking the earth at long. 266° 36′, and crossing the earth's orbit towards the sun at an angle of about 45° in the first, and of about 36° in the second case. The resemblance of the first case to the hyperbolic orbit of the Pultusk meteorites is remarkable by the large eccentricities and perihelion distances, the direct motion and small inclination to the ecliptic allowing each meteor to overtake the earth on paths that crossed its orbit towards their perihelion points at angles of about 45° and 11°. It should also be remembered that the meteor of Pultusk burst and disappeared at a height of 25 miles, and the present large fireball at a height of only 20 miles, as if its materials were tougher or more compact than the perfect shower of small stones that fell at Sielk from the point of the Pultusk meteor's explosion overhead. Both of these large fireballs were well seen and recorded at the Observatory of Breslau; and the concurrent testimony of two such well investigated cases is, as observed by Dr. Galle, strongly indicative of a tendency of aërolitic and detonating fireballs to belong to a class of astronomical bodies different from comets or annual

* From a slight change of inclination of the orbit, the descending here becomes the ascending node.

periodic star-showers by moving in hyperbolas instead of in parabolas or long ellipses, so as to have motions of their own beyond the sphere of the sun's attraction, carrying them apparently from star-system to star-system, instead of in constant revolutions round a single solar centre. Observations of the duration, length of path, and points of first appearance of meteors of the August and November star-showers Dr. Galle suggests will be most valuable to show if any shooting-stars of those well-known streams present speeds that cannot belong to other than hyperbolic orbits, as in those cases it must be assumed that the excessive velocities observed have their explanation in some physical cause, to which it will then be very desirable to direct special and the most accurate possible investigations.

The combination of at least two good observations needful for determining a shooting-star's real speed of flight is the difficulty that will present itself to carry out Dr. Galle's experiments on the Perseïds and other annual meteoric showers. This objection, however, does not apply to the apparent speed, if even a single observer records that speed without very serious errors; but even such a record is not often reached. Observers' estimates vary chiefly as to the apparent lengths of meteors' courses and their time of flight. An incomplete view of the course at the beginning, and sometimes also (from dimness of the meteor owing to distance) at the end, is often the cause of this, unsuspected by the observer. The time of flight and length of path recorded should, however, always correspond together, a short observed time of flight for a partially observed path being never coupled in a record with an ideal length of course supposed to make up the whole length of a meteor's line of flight judged by such indications of it as the meteor may have left. It may also be forgotten to record the times of flight of some shooting-stars at all—a very unfortunate omission, because the value contributed by such an observation to a simultaneous observation of the same meteor made at a distant station is enhanced immensely by a statement of this astronomically important datum. Much is due here to hurry in the rapid succession of meteors in periodic star-showers, and comparatively little to inability to note and appreciate small intervals of time. The best time for noting the duration (as well as the magnitude and colour) is while fixing with the eyes the position of the path just seen, often marked for some time after the meteor's disappearance by the persistent streak among the stars; and it can then easily be borne in mind, and presently afterwards recorded. Stop-watches, however, or chronographs of the best description, must be resorted to if results of the most reliable character only are desired to be obtained.

It may be added that if the visual radiant-point and the real height in miles at disappearance (h miles) are determined, and the following particulars of a meteor's apparent course are taken from a single observer's description of its apparent path, viz. the distance from the radiant-point in degrees (d) of the point of commencement, the altitude in degrees from the horizon (a) of the point of extinction, the length (l) in degrees of the apparent path, as well as the time of flight in seconds (s), then the real length of path (L) in miles is $\mathrm{L}=h\dfrac{\sin l}{\sin a \,.\, \sin d}$, and the real velocity in miles per second (V) is $\mathrm{V}=\dfrac{h}{s}\,.\,\dfrac{\sin l}{\sin a \,.\, \sin d}$. For many meteors of a shower, like the *Perseïds,* from a single radiant-point, an average value of h, about 52 miles, may be assumed; and an average real velocity of the meteors of the shower may then be obtained by the last of these expressions from careful observations, by a single observer only, of their times of flight or durations and apparent paths.

List of Meteor-heights and Velocities, August 1871 to August 1873; Calculated by Mr. T. H. Waller, with remarks and some additional Determinations by Professor Herschel.—Part I. Duplicate Observations of Shooting-stars contained in the Report for 1872.

Date.	Hour, Approx. G. M. T.	Places of Observation.	Apparent Magnitude, as per Stars &c.	Duration.	Height in B. S. miles at Beg.	Height in B. S. miles at End.	Length of Path. B. S. miles.	Velocity. Miles per Second.	Radiant-point. R.A.	Radiant-point. Decl.	Reference to Notes—thus, (4), (4 a); and Calculator &c.
1871. Aug. 10	h m s 10 51 15	Royal Observatory, Greenwich.	>♃	0·7 second							
10	10 51 0	Cardiff	=♀	...	85	60	55	(?)	Near δ or α Persei		(1); H.
10	10 45 0+	Portsmouth	Large	...							
10	10 50 0	Hawkhurst	Large	...							
11	0 31 0 a.m.	Manchester	Nucleus with sensible disk 2′ diam.	1·5 second	91	40	60	40	28°	+51°	(2); H.
11	0 30 0 a.m.	Radcliffe Observatory, Oxford.	>1st mag.	...	[118	70	66	43	54° (?)	+52° (?)	Comparison of Manchester with Leamington in old list.]
11	10 6 0	Hawkhurst			92·5	52·9	66	94	Between χ Persei and ε Cassiopeiæ.		W.
11	10 6 53	Royal Observatory, Greenwich.			85	45	50	70	29° (Near ε Cassiopeiæ.)	+61°	(3); H.
11	10 11 0	Hawkhurst			54·8	35·2	21·3	21	About 350°	+70°	W.
11	10 12 7	Royal Observatory, Greenwich			55	35	25	25	345°	+69°	(4), (4 a); H.
11	11 0 30	Bolton, near Manchester.			221	144	111	160	Near χ Persei		W.
11	11 0 48	Royal Observatory, Greenwich.			206	134	100	140	31°	+59°	(5); H.
					[92	58	54	(?)	35° (Near η Persei.)	+54°	York and Bolton (old list)].
11	11 16 0	London	1st mag.								
		Birmingham	>1st mag.	1·5 second	53·7	36·5	49·3	33	30°	+20°	T. H. W.
11	11 14 59	Royal Observatory, Greenwich.			77	40	56	37	50° (Near BC Camelopardi.)	+61°	(6); H.
					[103	63	73	49	40° (Near η, k Persei.)	+56°	London and Birmingham (old list)].

11	11 26 0	Birmingham	......	......	71·8	62·3	31·5	26	30°	+20°	W.
11	11 26 23	Royal Observatory, Greenwich	......	......	62	46	29	29	35° (Near θ Persei.)	+48°	(7); H.
11	11 34 0	Hawkhurst	......	......							
11	11 35 45	Royal Observatory, Greenwich	......	......	56·9	56·9	25·9	17	......		(8); W.
11	11 46 0	London	>1st mag.	......	87·1	44·8	58	44	Between η and χ Persei.		W.
11	11 45 30	Hawkhurst	> ♃	......	[64·5	41	36·5	......	42°	+52°	(8 a); W.]
11	11 46 56	Royal Observatory, Greenwich	......	......	[67	43	40	......	48° (Between γ and α Persei.)	+52°	London and Hawkhurst (in old list).]
11	11 50 30	Hawkhurst	......	......							
11	11 51 10	Royal Observatory, Greenwich	......	......	82·2	47·7	45	45	324° (In Pegasus.)	+13°	W. [A 'Pegasid' according to the observers' notes.]
11	11 54 35	Royal Observatory, Greenwich	......	......	69·5	46·1	24·1	34	Close to A Custodis (Bode).		(9); W. (a Perseïd).
11	11 55 0	Birmingham	......	......							
12	0 3 0 a.m.	Birmingham	......	......							
12	0 4 4 a.m.	Royal Observatory, Greenwich	......	......	94·3	63·3	72	90	Near ε Cassiopeiæ		W. (Perseïd).
12	0 29 0 a.m.	Hawkhurst	......	......							
12	0 29 25 a.m.	Royal Observatory, Greenwich	......	......	[246·7	134·5	116	97	337°	+55°	(10); W. Accordance very doubtful.]
12	10 46 10 p.m.	Royal Observatory, Greenwich.	=1st-mag.*	About 2 seconds.							
12	10 46 30 p.m.	Hawkhurst	= ♀	......	98·7	54·8	68·8	34·4	Close to A Custodis (Bode).		(11); W. (Perseïd).
13	9 32 0 p.m.	Hawkhurst	= ♀	......							
13	9 33 0 p.m.	London	Bright with bright streak.	......	24·7	15·7	......	......	284°	+60°	(12); W. (Draconid).
Dec. 12	10 13 0	Tooting, near London	......	......							
12	10 17 0	Hawkhurst	......	......	73·3	57·0	24	16	......		W.
1872. Jan. 2	11 29 0	Hawkhurst	......	......							
2	11 31 0	Eaton Square, London	......	......	44·2	42	40·1	20	......		(13); W.

List of Meteor-heights, &c.—Part I. (*continued*)

Date.	Hour, Approx. G. M. T.	Places of Observation.	Apparent Magnitude, as per Stars &c.	Duration.	Height in B. S. miles at Beg.	End.	Length of Path. B. S. miles.	Velocity. Miles per Second.	Radiant-point. R.A.	Decl.	Reference to Notes —thus, (4), (4 a); and Calculator &c.
1872.	h m s										
Jan. 2	11 33 0	Hawkhurst	...	...	45·4	43·7	28·5	20·3	...	...	(13); W.
2	11 33 0	Eaton Square, London	...	...							
2	11 54 0	Hawkhurst	...	...	64·6	45·4	48	24	...	...	(13); W.
2	11 54 30	Eaton Square, London	...	...							
April 19	11 7 0	Hawkhurst	...	...	87·5	52	37·2	15	...	...	W.
19	11 7 0	York	...	...							
19	11 26 0	Wisbeach	...	...	107	53	75·3	43	...	...	W.
19	11 28 0	York	...	...							

Part II. Duplicate Observations contained in the Report for 1873.

Date.	Hour, Approx. G. M. T.	Places of Observation.	Apparent Magnitude, as per Stars &c.	Duration.	Height Beg.	Height End.	Length of Path.	Velocity.	R.A.	Decl.	Reference to Notes
July 22	8 55 0 p.m.	Bridgewater, Somerset.	Large fireball	...	77·5	37·5	87·6	...	246°	−11° (? OZ ?)	(14); W.
22	8 55 0 p.m.	Dunmow, Essex	Large fireball	...							
Aug. 8	10 29 16	Bangor, North Wales.	3rd mag.	Very swift; 0·2 second	92·7	75	86·8	(?)	...	...	(15); W.
8	10 30 0	Royal Observatory, Greenwich.	3rd mag.	...							
8	10 39 50	Bangor, North Wales.	3rd mag.	Very swift; 0·2 second	76·7	60·0	66·3	(?)	40°	+43°	(15); W.
8	10 40 0	Royal Observatory, Greenwich.	1st mag.	...							
8	11 55 33	Lancaster	2nd mag.	...	86·2	59·0	40	53	46°	About +59°	W.
8	11 56 0	Royal Observatory, Greenwich.	3rd mag.	0·75 second							
8	11 55 30	Ibid.	2nd mag.	0·3 second	71·2	45·6	44·6	(68·6 ?)	61°	+63°	W.
8	11 56 0	Radcliffe Observatory, Oxford.	2nd mag.	1·0 second							
8	12 58 0	Ibid.	3rd mag.	...	111·2	41·4	79·6	[113·7 ?]	5°	+76°	W.
8	12 58 45	Royal Observatory, Greenwich.	1st mag.	0·7 second							

10	10 52 0	Birmingham	Sirius	1·0 second	97·6	76·3	66·5	44·3	....		W.
10	10 53 30	Prior Street, Greenwich.	> 1st mag......	2·0 second							
10	10 54 0	Tocting, near London.	>♀	1·5 second	127·3	80·8	87·9	70·4	....		W.
10	10 52 0	Birmingham	=Sirius	1·0 second							
10	11 18 0	Radcliffe Observatory, Oxford.	=3rd mag. ...	0·5 second	99	46·1	77·9	[107 ?]	41°	| +61°	W. (Perseïd).
10	11 18 30	York	=Sirius	1·0 second							
10	11 28 0	Ibid.	2nd mag.	0·5 second	70·7	66	20·4	[40·8]	61°	| +39°	W.
10	11 29 0	Radcliffe Observatory, Oxford.	4th mag.........	....							
10	11 34 0	Ibid.	2nd mag.	1·5 second	67·5	51·2	28·1	18·7	268°	| +80°	(16); W. (Polarid).
10	11 34 0	York	Sirius	1·5 second, slow.							
10	11 40 0	Radcliffe Observatory, Oxford.	4th mag.........	....	116·7	81·3	50·9	[101·8]	44°	| +59°	W. (Perseïd).
10	11 42 0	Birmingham	3rd mag.........	0·5 second							
10	11 44 0	York	3rd mag.........	1 second	69·1	......	....	....	....		Id. (Perseïd; near radiant-point; beginning, as seen at Oxford, calculated).
10	11 45 0	Radcliffe Observatory, Oxford.	4th mag.........	....							
11	10 25 30	Royal Observatory, Greenwich.	2nd mag.	0·5 second	57	21·9	35·2	70 ?	228°	| +57°	W. [Draconid ?].
11	10 26 0	Radcliffe Observatory, Oxford.	2nd mag.	Rapid							
11	10 26 30	Royal Observatory, Greenwich.	1st mag.	1·0 second	133·5	22·8	154 (?)	154 ?	....		W.
11	10 27 0	Radcliffe Observatory, Oxford.	3rd mag.........	Rapid							
11	10 38 0	York..............	1st mag.	0·75 sec. ...	48·8	41·6	47·5	55	127°	About | +48°	Id. (from unknown northern radiant-point).
11	10 39 0	Birmingham	1st mag.	1·0 second							
11	10 56 0	Birmingham	2nd mag.	>0·5 sec.	70	56	42·8	50±	54°	| +66°	W.
11	10 57 30	Royal Observatory, Greenwich.	1st mag.	1·0 second							
11	11 1 17	Ibid.	....	0·8 second	100·9	61	43·4	48	341°	| +52°	W.
11	11 3 0	York	2nd mag.	1·0 second							

List of Meteor-heights, &c.—Part II. (*continued*).

Date.	Hour. Approx. G. M. T.	Places of Observation.	Apparent Magnitude, as per Stars &c.	Duration.	Height in B. S. miles at Beg.	Height in B. S. miles at End.	Length of Path. B. S. miles.	Velocity. Miles per Second.	Radiant-point. R.A.	Radiant-point. Decl.	Reference to Notes —thus, (4), (4 *a*); and Calculator &c.
1872.	h m s										
Aug. 11	11 6 0	Regent's Park, London.	1st mag.	....	79·5	56·5	37·3	49·7	....	....	W. (Perseïd).
11	11 7 0	York	= ♀	0·75 sec.							
11	11 7 0	Royal Observatory, Greenwich.	3rd mag.	1·0 second	74·0	54·8	27·7	32·0	25°	+52°	(16 *a*).
				(Average results)	(76·8	55·6	32·5	35·9	25°	+52°)	
11	11 10 30	Ibid.	3rd mag.	0·5 second							
11	11 10 52	Ibid.	....	0·8 second	70·8	44·3	53·1	76 ?	73°	+70°	(16 *a*); W.
		[Positions not sufficiently exact.]									
11	11 11 0	York	= ♀	0·75 second							
11	12 11 0	Buntingford, Herts.	2nd mag.	1 second							
11	12 11 10	Prior Street, Greenwich.	1st mag.	1 second	84	74·1	54·9	55	87°	+47°	W.
11	12 18 0	Buntingford, Herts.	Sirius	1 second							
11	12 19 25	Royal Observatory, Greenwich.	....	1·3 second	57·7	21·2	54·0	46·9	(34°	+42° (?))	W.
	[12 19 28	Prior Street, Greenwich.	>1st mag.	1 second (?)	Apparent path crosses that observed at the Royal Observatory, Greenwich, almost at right angles.]						
Nov. 3	9 14 0	Portsmouth	Nucleus 10′ diam.	3·5 second	124·4	36·6	88·2	25	20°	+50°	W.
3	About 9 15 0	Bristol	Very bright	....							
28	10 25 0	Regent's Park, London.	1st mag.	Moved slowly	82·6	52·6	36·6	....	16°	+18°	W.
28	10 29 0± (approx. time).	Hawkhurst	1st mag.	Slow speed							
1873.											
April 19	10 42 30	Newcastle-on-Tyne.	1½ mag.	1·1 second	68·4	50·7	47·7	40 ±	274°	+26°	W.
19	10 44 0	York	1st mag.	About 1·5 second (with the streak).							

20	10 22 15	Newcastle-on-Tyne.	1½ mag.	0·6 second							
20	10 23 0	Sunderland, Durham.	2nd mag.........	....	71·6	53·0	....	....	257°	+34°	W.
20	11 7 0	Ibid.	4th mag.........	Quick							
20	11 7 0	Newcastle-on Tyne.	4th mag.........	0·8 second	53	42·4	....	....	170°	+77°	W.
20	11 15 15	Ibid.	3½ mag.	0·6 second							
11	11 15 30	Sunderland, Durham.	2nd mag.	Quick	120	88·3	....	....	255°	+15°	W.
Aug. 2	11 38 0	Radcliffe Observatory, Oxford.	1st mag.........	1 second ...							
2	11 40 0	Bristol	= ♃	0·8 second	52·2	28·2	24·4	27	316°	+45°	W. (Probably a Cygnid; ? BG).
11	9 11 0	Tooting, near London.	1st mag.........	....							
11	9 11 0	Bristol	1st mag.	0·8 second	67·2	44·9	23·6	15	256°	+50°	(17); W. (Draconid).
11	9 12 0	Radcliffe Observatory, Oxford.	1st mag.	2·5 second							
Oct. 18	10 46 0	Edgbaston, Birmingham.	1st mag.	1 second							
18	About 10 45 0 p.m.	Scots' Gap, near Morpeth, Northumberland.	1st mag.	1·5 second	108	104	....	....	113° (In Gemini).	+15°	(18); H. (Accordance doubtful and imperfect).
Dec. 11	10 38 45	Newcastle-on-Tyne.	= ♃	1·2 second							
11	10 39 0	Glasgow	= ♃	1·5 second	73	30	49	37	92° (Between θ Geminorum and β Aurigæ).	+44°	(19); H.
1874. April 20	10 50 0	Birmingham	=Sirius	1·25 second							
20	10 51 0	Weston-super-Mare, Somersetshire.	1st mag.........	About 0·75 second	80·9	64·7	19	About 19	Radiant $S_{5, 6}$		(20); W.
20	10 55 0	Ibid................	1½ mag.	0·5 second							
20	10 55 0	Birmingham	Sirius	1·0 second	115	74	....	....	Lyraïd (?)		(20); W.
Aug. 10	11 53 0	Ibid.	1st mag.; then >♀.	6·0 second	77*	50†	105	17	325° (? Tupman 44, July 28; or H. & N., Σ_1, Σ_2, July–August).	−17°	(21); W. H. Wood.
10	11 53 50	Newcastle-upon-Tyne.	= ♀	2·8 second, while in sight.		33‡					

* First appearance. † First extinction or explosion and deflection. ‡ Disappearance.

Notes to a List of Meteor-heights, &c.
By Mr. Waller *and* Professor Herschel.

(1) The brightest meteor noted on the 10th of August, 1871, descended almost to the S.W. horizon, from close to Saturn, at Portsmouth (J. P. Maclear), from the direction of *a* Capricorni at Cardiff (G. H. Thompson), in the direction of 60° W. of Magnetic South at Hawkhurst, and from 12° below and right of "Antares," at the Royal Observatory, Greenwich. The star Antares had set at Greenwich some minutes at the time of the meteor's appearance, and the planet Saturn was evidently mistaken for it. A distance of 8° below and right of Saturn at Greenwich, and of only 3° from Saturn in the same direction at Portsmouth, corresponds very exactly with the points of appearance of the meteor, as described at Cardiff in South Wales and at Hawkhurst in Kent. The length of path of the meteor seen at Greenwich is said to have been 5°, and the point of disappearance of the meteor, where it burst into fragments like a shell, is more or less distinctly recorded at the other stations. The height and position of this fine meteor's path are thus fixed with considerable certainty, and its identification with some of the bright bolides, reported by Mr. Le Verrier's staff of observers to have been seen at the same time at St. Lo in Calvados, and at Angers on the Loire, may be the means of fixing its true course and perhaps its real velocity, for which the very distant observations in England were ill adapted, with greater accuracy. The real course was over the northern part of the mouth of the Bay of Biscay, beginning about 70 miles south, and ending about 120 miles S. by W. from Brest, in longitudes and north latitudes respectively of about 5° W. from Greenwich, 47° 20′ N., and 5° 35′ W. from Greenwich, 46° 30′ N. No sensible appearance of a persistent streak was recorded, probably from the appearance of the meteor to all the observers among the cloudy vapours of the horizon; and from this circumstance of its low apparent elevation and very distant southern apparition, a bright meteor seen almost simultaneously with it at some considerable altitude in the south-western sky, at the Luxembourg Observatory in Paris, by Mr. Chapelas Coulier-Gravier, though otherwise resembling it in description (as noted in the list of meteor accordances of last year's Report), was certainly distinct, and not identifiable with this bright fireball of the "Perseïd" shower. In deducing its real height an addition of between 20 and 30 miles is made as an allowance for the curvature of the earth's surface at the great distance of between 400 and 450 miles from Greenwich, at which the meteor entered the atmosphere and pursued its course through the air.

(2) The rough note (in a Birmingham newspaper) of the apparent place of this meteor's streak at Leamington, or of the last fading part of it, before it disappeared "extending N. to S. across the chief stars of Cassiopeia, 3° or 4° long, and fading away in 15 seconds," may have related to its position after it became serpentine and was displaced by air-currents: compared with Mr. Greg's observations of the meteor at Manchester in the older list it led to an excessive height of the streak-bearing portion of the meteor's flight, which was certainly from the "Perseïd" radiant-area, and to no satisfactory indication of its radiant-point. The present observation of the same meteor by Mr. Lucas at the Radcliffe Observatory, Oxford, combined with Mr. Greg's excellent description of it at Manchester, supplies an estimation of its real path, length of course, and velocity, which is probably a much nearer approximation

to the truth. The point of appearance was nearly over Newark, and that of disappearance nearly over Derby in the Midland Counties, at heights of about 90 and 40 miles respectively, the brightest and most enduring portion of the bright streak being left, apparently, at a height of about 54 miles on this course. The radiant-point given by the Oxford and Manchester observations is a few degrees distant, in the direction of Andromeda, from the cluster (χ) in the sword-hand of Perseus.

(3) The extent of the meteor's flight at the beginning and end of its apparent course at Greenwich is not stated, leaving the corresponding heights, and the resulting length of path and velocity of the meteor from these observations, unverified and doubtful. The meteor's radiant-point between χ Persei and ϵ Cassiopeiæ is probably very well established, and it accordingly formed one of the meteors of the "Perseus" shower.

(4) The recorded paths are in very good accordance with a radiant-point near ψ or ι Cephei; the meteor belongs to a contemporary shower from Cepheus or the North Pole, adjoining one between Draco and Cepheus frequently observed (with but slight intensity) on or about the same date as the Perseïds of the 10th of August. The declination of its radiant-point appears too northerly to allow it to be regarded as a very erratic Perseïd.

(4*a*) The recorded appearance at the Royal Observatory, Greenwich, of a bright meteor at $10^h\ 15^m\ 9^s$ (> ♃, &c.) on the 11th of August, 1871, nearly simultaneous and agreeing in all other particulars of its appearance with a meteor observed nearly at the same minute at York, Hawkhurst, and in London (whose height was thence calculated in the older list), is unfortunately of no useful service to afford a redetermination of the height, the region bare of stars in which it appeared having evidently afforded no visible sky-marks for its accurate registration. The direction of its flight, however, confirms the position of the radiant-point (near B Camelopardi) adopted rather than obtained directly from the three independent observations of its course already used, and renders the height and velocity of this true Perseïd thus arrived at in the former list very probably correct.

1871, August 10.	h m 10 14–15 p.m.	York, London, Hawkhurst.	=1st mag. *, ♃, or ♀.	Began 85 miles high.	Ended 53 miles high.	Length of path 53miles.	Velocity 35 miles per second.	Radiant-point $\alpha = 44°$, $\delta = +60°$ near B Camelopardi.

(5) The meteor recorded as a simultaneous observation (in last year's Report) between Prior Street, Greenwich, and Bolton near Manchester, at $11^h\ 0^m\ 48^s$ on the 11th, was contemporaneously noted at York; and the combined paths at York and Bolton afforded a determination of this meteor's height in the earlier list of a perfectly ordinary kind. The meteor seen at Greenwich is not in proper position for coincidence with York, and when compared with Bolton the resulting parallax is so small that, with the great base-line between Manchester and Greenwich, an extravagant scale of heights, length of course, &c. is obtained. It must indeed be evident that a meteor already some distance north of east at York and Manchester (in the constellations Andromeda and Aries) must have appeared at Greenwich much further transferred towards the north horizon by the effect of parallax, than to a course in Perseus "across the star δ" (then at a great elevation in the N.E. sky) along which it seemed to move. Thus, as in the last instance, the present Greenwich observation cannot be regarded as affording fresh materials for verifying the earlier list, a different meteor having evidently been seen at

Greenwich in this case with all its features, except those of verified positions, sufficiently resembling the descriptions of a meteor elsewhere doubly mapped and calculated to have led it without this certain difference to have been treated as identical with it, and hence (if the distinction were not observed) to have been coupled with it in an average result.

(6) The path of this meteor was well mapped at Greenwich, and it is in excellent agreement with the apparent course as seen at Birmingham. The original observation of its track by Mr. Crumplen in London is marked "imperfect view;" and lying as it does transversely as well as at a considerable distance from the course shown at Greenwich (very near to London), it may be assumed that the apparent path mapped at Greenwich is more reliable, and that the above calculations of the real heights, length of path, and velocity from the Greenwich and Birmingham observations, are more nearly accurate than those obtained by comparison of London and Birmingham in the older list. Mr. Waller's and Prof. Herschel's calculated paths differ greatly in the Table, the cause of which is not improbably an uncorrected printer's error, $8°+56°$ instead of $8°+86°$, accidentally inserted in the catalogue of the last Report as the meteor's point of first observation by Mr. Wood at Birmingham, the existence of which was only noticed when Mr. Waller's calculations had already been completed.

(7) Doubtful conditions of the recorded paths appear in this instance to lead to very uncertain determinations of the real course.

(8) Probably a "Cygnid," from its apparently foreshortened paths near that constellation; but found by Mr. Waller's determination of the real from the described apparent positions of its course to have had a nearly horizontal motion. The original observations are evidently unable to afford, without notable concessions, a radiant-point near enough to the observed paths to be regarded as a proper explanation of their curtailed and apparently foreshortened lengths. This Greenwich meteor at $11^h\ 35^m\ 45^s$ P.M., Hawkhurst $11^h\ 34^m$ P.M., is quite distinct from the true Perseïd simultaneously observed at $11^h\ 36^m$ P.M. at Hawkhurst and London (recorded in the earlier list), the times at Hawkhurst and London having all been between 1^m and 2^m slow on Greenwich time throughout the watch.

(8*a*) The Greenwich observation of this meteor (if they are really identifiable) is so much at variance with the Hawkhurst observation as scarcely to permit of the height determination that Mr. Waller has endeavoured to obtain from them. The London and Hawkhurst observations (of the old list) agree well together, and Mr. Waller's recalculation of them (as will be seen in the Table) leads very nearly to the heights &c. already found. The view of the meteor at Greenwich was probably imperfect; but errors may also have been made at Hawkhurst and in London; and in such cases it would be very desirable to share the errors as far as possible equally among the different observers.

(9) A meteor simultaneously observed at about this time (11^h 53–54^m) at Hawkhurst and London (in the old list) was a "Polarid;" and although appearing in nearly the same quarter of the sky with the "Perseïd" mapped at Birmingham and at the Royal Observatory, Greenwich, it is found by projection of the apparent paths to be irreconcilable with and quite distinct from it, these two duplicate observations having thus been obtained (like the two last described) independently of each other in a brief interval of scarcely more than a minute's watch.

(10) The hour at Hawkhurst ($0^h\ 29^m$ A.M.) is scarcely half a minute

instead of, as usual during this night, a full minute, or considerably more than a minute slow on the Greenwich time of observation ($0^h\ 29^m\ 25^s$); and although in all respects of appearance and relative position, excepting an extremely small parallax of about 10° or 12° near the zenith, the meteor descriptions at Hawkhurst and the Royal Observatory, Greenwich, are in very good agreement, the sensible difference of the times and the excessive length of path and velocity as well as the extravagant real heights of the meteor's course to which the observations lead, make it manifest that the supposed identity of these meteors is mistaken, or that if the resemblance was real, and not merely accidental, the errors singularly made in recording the apparent paths are such as to prevent entirely any satisfactory calculations from being founded on them.

(11) A large and bright Perseïd leaving a long enduring streak that remained visible at Greenwich about 15 seconds. The meteor's course well observed at both places.

(12) The evidence of identity in this duplicate observation is by no means certain. On the other hand, from the brightness and unusual direction of the meteors, and from the near coincidence of the times, it is extremely probable. Even if it can be assumed that no errors have crept into the descriptions of the two apparent paths, that noted by Mr. E. Neisson in London, "from Cepheus to Perseus," admits of very wide interpretations. Both observations are probably open to very considerable emendation; but it cannot be denied that, as they stand, if they refer to one and the same shooting-star, its real elevation above the earth's surface was far inferior to what is usual in ordinary meteors, and ranged no higher than the lowest points (between 25 and 15 miles above the sea-level) to which detonating and aërolitic fireballs sometimes penetrate the earth's atmosphere. The absence of good evidence both of identity and accuracy in the observations must, however, leave this general conclusion from them very doubtful.

(13) The three meteors of the January star-shower in 1872, doubly observed at Hawkhurst and in London on the 2nd of January, 1872, were bright ones of a very fine return of that periodic shower, and they were carefully recorded. Their general elevation appears to have been lower than that of ordinary shower-meteors, and a good average velocity of about 21 or 22 miles per second (which is a very moderate meteor-speed) appears to have been obtained. Comparisons of this meteor-speed with the known elements and theoretical meteor-speed of the January meteor-stream will afford an interesting subject of investigation.

(14) Calculated real height and path from two of the most accurate among many general descriptions of the course of this large meteor seen at many places in the south of England in strong evening twilight on July 22nd, 1872.

(15) Two small shooting-stars simultaneously observed in a combined watch of the August shooting-stars kept by Prof. G. Forbes at the Royal Observatory, Greenwich, and Captain G. L. Tupman at Bangor in North Wales.

(16) 1872, August 10th, $11^h\ 34^m$ P.M., Oxford and York. Apparently a very good determination of the height, speed, and direction of the real path of a meteor from a well-known coradiant of the August shower close to Polaris.

(16*a*) Two bright meteors seen at York by Messrs. Clark and Waller, and

by Prof. G. Forbes at the Royal Observatory, Greenwich, as well as by Mr. Glaisher's staff of observers there, and by Mr. Crumplen in London.

(17) A rather bright meteor unconformable to Perseus at 9^h $11–12^m$ P.M., August 11th, 1872; simultaneously observed at three stations, appearing with yellowish light, slow speed, and somewhat crooked course. Carefully observed at all the stations, and the resulting heights, &c. probably pretty accurate.

(18) A bright "Orionid" of the annual October shower, with long course of 40° along the southern horizon at Scots' Gap, Northumberland, and falling nearly vertically in the west; length of path about 20° at Birmingham. The view at Scots' Gap near the horizon was unfavourable for exact description by the stars, and the recorded time of appearance at Scots' Gap was five minutes earlier than at Birmingham, where the meteor noted was the first recorded on that night. It is very doubtful if the same meteor was simultaneously observed, each of two bright meteors of the shower having apparently been seen at one, which was at the same time unnoticed at the other station.

(19) A small bolide of the December shower, which was observed simultaneously at Glasgow and at Newcastle-upon-Tyne, on December 11th, 1873. The meteor appeared close and bright at both the stations, and of distinct greenish light at Newcastle-upon-Tyne, where it really descended at a distance of 150 miles towards the east, or two fifths of the way across from the English to the Danish shore of the German Ocean; and the length, height, and position of its luminous track were fixed with great accuracy by the duplicate descriptions of its course.

(20) These two meteors simultaneously observed at Birmingham and Weston-super-Mare by Mr. Wood and Mr. T. H. Waller, with foreshortened courses near their respective radiant-points, during the April meteor-shower in 1874. The first, directed from Comæ Berenices, presents a very satisfactory accordance. The agreement of the recorded paths of the second, from Lyra, is less exact; but the extreme shortness of its visible path at Weston-super-Mare may have made it rather more difficult to describe its course and its apparent position there correctly.

(21) A fine bolide, unconformable to the shower from Perseus, seen during the meteor-shower on August 10th, 1874, at Birmingham and at Newcastle-on-Tyne. The real height, speed, length of path, and direction are well defined by the observations as far as the last point of principal explosion. The meteor then continued its path for some distance as a ruddy fragment, which, from the low view of the meteor near the horizon, was not visible at Newcastle-upon-Tyne; it inclined downwards, at the same time, in its direction until it disappeared. Mr. Wood has calculated the following real heights and positions of the meteor at the three principal points upon its course.

He adds that the observations indicate a radiant-point of the meteor's course at about $\alpha = 325°$, $\delta = -17°$, which is close to positions well defined by Captain Tupman (No. 44), at 326°, −13° on July 28th; by Dr. Schmidt, at 332°, −14° from July 20th to 31st, and August 3rd to 31st; and by Heis and Neumayer (Σ_1, for August) at 337°, −10°,—forming a distinct radiant-region in Aquarius along a part of the southern arc of the ecliptic at that season of the year.

"*Approximate path of the Meteor.*—From near Caermarthen to a point 15 miles off the N.W. coast of Anglesea. Point of first extinction or explosion =7 miles N. of Bordsey Island.

	(1) Over Caermarthen.	(2) Over Bordsey Isl.	(3) Over point off Anglesea.
Altitudes in miles	77	50	33
Distant from Birmingham ..	112; S. 70° W.	119; N. 76° W.	
Distant from Newcastle	240; S. 29° W.	190; S. 41° W.	

"Length of path 105 miles, direction 7° E. of south, inclination to horizon 16°, velocity 17 miles per second, amount of deflection 9 miles vertically down in a path of 36 miles from position No. 2; distance of companion from nucleus ½ mile, thus:  (distance asunder 12′, between α and β Coronæ)."

II. Aërolites.

It is noticed in the 'American Journal of Science' of September 1873, that a mass of meteoric iron found at Neuntmannsdorf, in Saxony, in December 1872, weighing 25 lbs., has been deposited in the Museum at Dresden.

In the 'Comptes Rendus' (vol. lxxix. p. 276, August 3rd, 1874) are communications by M. Daubrée on the recent aërolitic falls of Vidin (Turkey) and St. Amand (France), of which the following are abstracts.

Virba, near Vidin, Turkey, May 20, 1874.—An aërolite weighing 8 lbs. fell with the usual loud explosions, and penetrated the earth to a depth of about 1 metre (3¼ feet). It was entirely coated over with a dull black crust, and, as preserved in photographs, its form appears to have been fragmentary. The substance of the stone is light grey, fine-grained, with a rough fracture and occasional globular structure. Fine grains of metallic nickeliferous iron and impalpable particles of chrome iron and sulphuret of iron are scattered through it. The mineral portion is partly attackable (peridot) and partly unattackable (enstatite) by hydrochloric acid. The attackable part forms fully one half of the meteoric mass. It is thus a meteorite of the most common species, like that of lucé or lucéite. The following aërolites are cited by M. Daubrée as resembling it:—Bachmut, 1814, February 15; Politz, 1819, October 13; Angers, 1822, June 3; Mascombes (Corrèze), 1835, June 30; Iowa (U.S.), 1847, February 25; Ski (Norway), 1848, December 27; Œsel Isle, 1855, May 11; Saint-Denis (Western Belgium), 1855, June 7; Buschoff (Kurland), 1863, June 2; Dolgowola (Volhynia), 1864, June 26.

Saint-Amand, Loir-et-Cher, France, July 23, 1872.—In addition to the fragments of this fall found at Lancé (104 lbs.) and at Pont Loiselle (½ lb. in weight), the latter fragment ten kilometres (6¼ miles) from the former (see these Reports for 1873, p. 384), M. Daubrée relates that four other fragments, weighing between 7 lbs. and ¾ lb., have since been discovered. Two of them, weighing about 1½ lb. each, were found 100 metres apart, while the other two struck the ground some miles from them and from each other.

III. Large Meteors and Meteor-Showers.

The following catalogue includes the observations of large meteors during the past year of which accounts have reached the Committee.

LARGE METEORS OBSERVED IN THE YEAR 1873–74, O[...]
SOURCES DURIN[...]

Date.	Hour, approx. G. M. T.	Place of Observation.	Apparent Magnitude, as per Stars &c.	Colour.	Duration.	Apparent Path.
1821. Sept. 24	h m s About 8 0 p.m. (local time).	Beinsuef (above Cairo), on the Nile.	Fireball twice the apparent size of a man's fist.	....	....	First observed i[...] the zenith.
25	3 43 a.m. (local time).	Ibid...............	....	....	....	In the southern sk[...]
26	9 53 p.m. (local time).	Ibid...............	Dazzlingly bright, and apparently as large as the full moon.	....	Remained in sight about 3 seconds.	Appeared near t[...] north-west hor[...] zon.
1822. Apr. 12	One hour after sunset.	Argo Isle (on the Nile), Dongola.	Large fireball; nucleus with large apparent disk.	....	....	....
Aug. 17	About 4 0 a.m. (local time).	Embukol, Upper Dongola.	Large meteor	....	....	Passed across t[...] zenith.
31	About 4 0 a.m. (local time).	Ibid...............	Large shooting-star.	....	....	....
1825. Jan. 31	Before daylight.	Ga el ma, near Jedda, Arabia.	Six fine shooting-stars in $2\frac{1}{2}$ hours.	....	....	....

PREVIOUSLY OBSERVED AND FIRST DESCRIBED IN PRINTED
THE PAST YEAR.

Length of Path.	Direction or Apparent Radiant-point.	Appearance; Remarks.	Observer.
....	Travelled exactly from west to east.	When it had advanced but a few degrees eastwards from the zenith the nucleus disappeared, and the following spark-trail included many (four at least were counted) bright fiery fragments. No sound was heard.	C. G. Ehrenberg. Physical observations in Northern Africa and Western Asia. (Poggendorff's Annalen, Jubelband, 1874, p. 612.)
....	....	Meteor itself not seen; on turning round towards the south, its streak alone remained in sight, between α Orionis and Sirius, brightest at the north end, milk-white, where the light cloud continued visible two minutes, three times the length and about one fourth of the width of one apparent diameter of the full moon, when it was first observed.	Id. Ibid. (Ibid.)
....	Moved from S. to N.	....	Id. Ibid. (Ibid.)
....	From S.E. to N.W.	The nucleus shone with intensely strong light, but scattered no sparks. Such large meteors, the Arabs informed Professor Ehrenberg, were of not uncommon occurrence in their countries; but of a real fall of aërolites they appeared to have no definite traditions.	Id. Ibid. (Ibid.)
....	....	Left a long and brilliant streak that remained visible some time, even when the gaze having for a moment been averted was again directed towards it, before it disappeared.	Id. Ibid. (Ibid.)
....	....	Left a persistent light streak divided into two at the middle of its length by a dark space, and evidently, therefore, material or substantial in its character.	Id. Ibid. (Ibid.)
....	....	All left very long enduring streaks	Id. Ibid.

Date.	Hour, approx. G. M. T.	Place of Observation.	Apparent Magnitude, as per Stars &c.	Colour.	Duration.	Apparent Path.
1869. Feb. 11	h m s 5 31 36 p.m.	Malta	= Mars	Orange-red, like Mars.	Slow steady speed; 3 seconds.	$\alpha=$ $\delta=$ From $124\frac{1}{2}°$ $+34°$ to $146\frac{1}{2}$ 0
17	2 59 48 a.m.	Ibid.	= ♃	White	1 second	$\alpha=$ $\delta=$ From $229\frac{1}{2}°$ $+52°$ to $204\frac{1}{2}$ $+35$
Apr. 8	0 29 0± a.m.	Ibid.	10′ diameter, many times > ♀	White	5 to 7 seconds; moved very slowly.	$\alpha=$ $\delta=$ From $155\frac{1}{2}°$ $+11°$ to 151 $+4$
Aug. 9	0 50 a.m.	Between Rome and Sardinia.	= ♃	White	0·5 second	$\alpha=$ $\delta=$ From $48\frac{1}{2}°$ $+3°$ to 56 $+26$
Sept. 9	1 14 a.m.	Near Tunis (Africa).	= ♀	Orange colour	1·5 second; slow speed.	$\alpha=$ $\delta=$ From 75° $+60°$ to 61 $+51\frac{1}{2}$
20	10 37 p.m.	Ibid.	= ♀	Very deep orange colour.	2·5 seconds; slow and uniform motion.	$\alpha=$ $\delta=$ From 20° $+44°$ to 47 $+53\frac{1}{2}$
Oct. 3	0 14 a.m.	Near Algiers (Africa).	= ♃ or Mars	Orange colour (?).	4·5 seconds; very slow.	$\alpha=$ $\delta=$ From 39° $-14\frac{1}{2}°$ to 48 $-15\frac{1}{2}$
5	5 57 0±	Near Oran (Africa). N. lat. 36° 32′, long. 1° 0′ W. from Greenwich.	Large fireball; diameter 5′.	Nucleus vivid emerald-green; posterior part crimson; sparks white or yellow.	5 seconds	Altitude about 38° N. 40° E. to altitude 15° N. 8° E.
12	2 2 36 a.m.	Near Malta	=3rd, then =1st mag.*; then 3′ or 4′ in diameter.	White, then deep dull red.	16 seconds, carefully counted; at first rapid, then slackening its speed until it seemed to stop altogether as it died out.	$\alpha=$ $\delta=$ From 71° $+15°$ to 97 -26
13	0 23 36 a.m.	Ibid.	= ♀	White	1 second	$\alpha=$ $\delta=$ From 55° $+2\frac{1}{2}°$ to 36 $+14$
13	0 59 6 a.m.	Ibid.	= Mars or ♃	White	0·3 second	$\alpha=$ $\delta=$ From 107° $+13°$ to 109 $+1$
13	2 14 30 a.m.	Ibid.	= Mars or ♃	White	0·3 second	$\alpha=$ $\delta=$ From $74\frac{1}{2}°$ $-5°$ to 68 -14
13	2 22 18 a.m.	Ibid.	= Mars or ♃	White	1 second	$\alpha=$ $\delta=$ From 66° $+8\frac{1}{2}°$ to 76 $+4$
15	2 13 18 a.m.	Ibid.	= Mars or ♃	White	0·7 second	$\alpha=$ $\delta=$ From $108\frac{1}{2}°$ $-4°$ to 97 $-17\frac{1}{2}$
Nov. 4	2 40 30 a.m.	Ibid.	= Mars or ♃	White	1·5 second	$\alpha=$ $\delta=$ From 83° $-7°$ to 93 -13

Length of Path.	Direction or Apparent Radiant-point.	Appearance; Remarks.	Observer.
40°	....	Uniform in brightness. Passed near Mars. Seen in twilight.	G. L. Tupman. (Observations of shooting-stars, 1869–71.)
27°	....	Left a streak 10° long for 2 secs.	Id.
8°.............	....	Like the electric light, shed a strong light around. Died out, leaving two reddish sparks, which disappeared immediately.	Id.
25°	T 47; in Eridanus	Left a streak 5° long for 1 second	Id.
....	....	A very fine meteor; left a streak 4° long.	Id.
16°	....	Nucleus with short train of sparks	Id.
9°	....	Nucleus with train of sparks; left a streak.	Id.
35°	....	In broad daylight, a few minutes after sunset. The vivid green colour of the meteor most remarkable, like burning barium.	Id.
50°	Fell exactly vertically............	Nucleus followed by a short train of red sparks. Expanded on its course from 3rd magnitude and white to 1st magnitude, deep dull red; slackening its speed most singularly.	Id.
22°	October radiant near Rigel ...	Left a streak 10° long for 2 secs.	Id.
12°	October radiant near Castor and Pollux (G No. 105, S and Z No. 161).	Left a streak 4° long for 2 secs...	Id.
11°	Orionid (No. 104 G)	Left a streak 4° long for 2 secs...	Id.
11°	R_3 in Aries and Musca (No. 94 G).	Left a streak 2° long for 1 sec....	Id.
17°	(October Gemini radiant?) ...	Left a streak 4° long for 2 secs...	Id.
13°	R_3 (Aries and Musca; G 94 or 109).	A very fine meteor; left a streak 3° long.	Id.

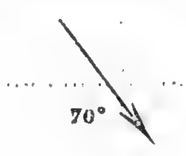
Date.	Hour, approx. G. M. T.	Place of Observation.	Apparent Magnitude, as per Stars &c.	Colour.	Duration.	Apparent Path.
1869. Nov. 4	h m s 2 58 42	Near Malta	= ♀	White	2·7 seconds ...	$\alpha=$ $\delta=$ From 95°−15° to 110 −24
10	1 37 a.m.	Near the Isle of Rhodes.	= Mars or ♃	White	Very rapid; 0·2 second.	From 70°+13° to 55 + 7
10	5 39 0+ p.m.	Ibid.	= Mars or ♃	White	2·2 seconds ...	From 31°+6° to 13 −3
10	6 14 0± p.m.	Ibid.	= Mars or ♃	White	2 seconds......	From 38°+41° to 58 +43
13	0 50 42 a.m.	Ibid.	= ♀	White	0·2 second ...	From 152°+43° to 163 +63
14	1 to 3 a.m.	....	....	....	....	....
Dec. 21	5 5 54 p.m.	Near Malta	= ♀	Intense white	About 5 secs...	$\alpha=$ $\delta=$ From 340°−42° to 9 −49 (Course while in sight; commencement not seen.)
1870. Jan. 5	3 23 12	Ibid.	= ♀	White	4½ seconds ...	$\alpha=$ $\delta=$ From 165°+48° to 209 +30
Mar. 11	1 58 a.m.	Ibid.	= Mars or ♃	Deep red	Rather slow speed; 2·5 seconds.	From 175°+36° to 187 +14
Apr. 26	0 50 a.m.	Ibid.	= Mars or ♃	White	3 seconds......	From 270° +10° to 266 +53
May 3	2 36 a.m.	Near Catania (Sicily).	= ♀	White	0·7 second ...	From 300° −16° to 275 −21½
3	2 40 a.m	Ibid.	= Mars or ♃	White	1 second	From 289°+2½° to 260 +6
3	2 47 a.m.	Ibid.	= ♀	White	....	....
4	2 27 a.m.	Ibid.	= Mars or ♃	White	....	From 12°+70° to 124 +62
June 29	2 2 a.m.	Near Malta	= Mars or ♃	White	1 second	From 321° +4½° to 328 +7½
29	2 52 a.m.	Ibid.	Very many times > ♀.	White	....	From 10°−10° to 330 −25
July 9	2 11 a.m.	Near Girgenti (Sicily).	= ♀, 5′ or 7′ in diameter.	Vivid green ...	Very slow; 4 seconds.	From 233°+34° to 224 +27½
20	7 30 p.m.	Near Messina (Sicily).	= Mars or ♃	White	3 seconds......	From 295°+45° to 246 −12
21	10 14 p.m.	Ibid.	= ♀	Blue (?)	3 seconds......	From 285°−23° to 294 −37
28	1 2 a.m.	Near Malta	= Mars or ♃	White	Slow; 1·2 sec.	From 346°−9° to 355 −9½
28	2 34 a.m.	Ibid.	= Mars or ♃	White	0·2 second; very swift.	From 350°+28° to 337 +10
29	2 25 a.m.	Ibid.	= Mars or ♃	White	1 second; slow	From 305° +18° to 303½ +24

Length of Path.	Direction or Apparent Radiant-point.	Appearance; Remarks.	Observer.
18°	R_3 ? (same radiant as the last).	A very fine meteor with a short train of sparks. Point of disappearance very accurate.	G. L. Tupman. (Observations of shooting-stars, 1869–71.)
17°	Leonid	Left a streak 6° long for 1 sec.	Id.
20°	Taurid	Left a streak 10° long for 2 secs.	Id.
15°		Left a streak 1° long	Id.
21°		Very fine meteor; left a streak 5° long, 20′ broad, for 5 seconds.	Id.
	T 100	Shower of fine meteors from Leo; radiant-point 151°+21°·5.	Id.
20°		Like Venus in motion; very fine meteor. Left scarcely any train. Velocity decreased almost to stopping when it disappeared.	Id.
42°	Radiant near θ Ursæ Majoris, $M_{1,2}$.	Very fine meteor with train 7° or 8° long, but it left no streak.	Id.
24°		Nucleus with train of sparks; left no streak.	Id.
43°	From a low southern radiant-point (T 29).	Very fine meteor with a train 15° long; left no streak.	Id.
25°	Alpha-Aquariid. (325−2½.) (T 33; ? a branch radiant of Halley's comet.)	Left a very brilliant streak 8° long, 1° broad, for 2 seconds.	Id.
29°	Same radiant as the last	Very fine meteor, leaving a streak 10° long.	Id.
	From the same special radiant-point as the last.	A very fine meteor	Id.
40°	Heis A_8		Id.
8°	Between Antinoüs and Sagittarius, 290 −15 (T 36, 37).	Left a streak 2° long for 3 secs.	Id.
40°		Seen in daylight	Id.
10°	$B_{1,2}$ (?)	Nucleus with a very short pointed train of sparks.	Id.
70°	B_4 or B G (?)	Left a streak 25° long for 3 secs.	Id.
16°	Schmidt, July, 279°+1°	A very fine meteor	Id.
9°	δ Aquarii (T 43, 44; Southern radiant of July and August, 340 −15).	Left a streak 4° long	Id.
21°	Perseïd. Eight or ten meteors on this morning from a very definite radiant-point near α Andromedæ (T 45).	Left a streak 7° for 3 seconds	Id.
6°	Neumayer's Ξ_1 (305 − 7), near α Capricorni and μ ε Aquarii. (Norma Aquarii.)	A fine meteor, leaving a streak 2° long.	Id.

Date.	Hour, approx. G. M. T.	Place of Observation.	Apparent Magnitude, as per Stars &c.	Colour.	Duration.	Apparent Path.
1870. July 31	h m s 1 21 0	Near Malta	= Mars or ♃	White	0·8 second ...	α= δ= From 14°+5° to 351 −13
31	1 24 30	Ibid.	= Mars or ♃	....	1 second; very slow.	From 337°−16° to 333 −12
Aug. 5	8 0 p.m.	Near Tunis (Africa).	= Mars or ♃	Very red colour.	2 seconds......	α= δ= From 338°+83° to 194 +53
6	2 5 a.m.	Ibid.	= Mars or ♃	White	2 secs.; slow..	From 13°−7° to 33 −5
7	1 43 a.m.	Near Bona (African coast).	Very large meteor	White	1·5 second ...	From 245°+36° to 228 +40
9	3 43 a.m.	Near Algiers (Africa).	= ♀	Red	0·6 second ...	From 0°+75° to 292 +68 (Seen through thin cloud.)
10	3 24 a.m.	Near Oran (Africa).	= ♀	White	0·5 second ...	α= δ= From 98° +35° to 104 +27
10	3 46 a.m.	Ibid.	= Mars or ♃	White	2 seconds......	From 120°+87° to 124 +67
10	3 53 a.m.	Ibid.	= Mars or ♃	White	0·6 second ...	From 68°+65° to 83 +67
14	9 42 p.m.	Gibraltar	= Mars or ♃	Ruddy	2 secs.; slow..	From 220° 0° to 213 0
29	3 55 a.m.	Near Oporto (Portugal).	= Mars or ♃	White	0·3 sec.; swift	From 30°+17° to 10 +27
30	3 0 a.m.	Ibid.	= ♀	White	0·4 sec.; swift	From 7°+46° to 340 +30
31	3 55 a.m.	Ibid.	= Mars or ♃	White	0·5 sec.; swift	From 345°+68° to 308 +55
Sept. 6	2 55 30 a.m.	Cape St. Vincent (Portugal).	= Mars or ♃	White	0·5 sec.; not very swift.	From 338°+35° to 320 +53
6	3 0 a.m.	Ibid.	= Mars or ♃	Reddish	2 secs.; slow..	From 347°+15° to 0 +45
6	4 24 a.m.	Ibid.	= ♀	White	0·2 sec.; very swift.	From 65°+46° to 99 +47
Dec. 12	5 30 p.m.	Malta	Very large fireball	?	?	From 355° −18° to 315 −32 (Position of the streak.)
12	6 57 p.m.	Ibid.	= Mars or ♃	White	3 secs.; slow..	α= δ= From 81°+25° to 45 0
12	7 18 p.m.	Ibid.	= ♀	Green	2 secs.; slow..	From 105°+54° to 103 +74
12	7 32 p.m.	Ibid.	= ♀	Bright green...	2 secs.; rather slow.	From 68°+41° to 45 +41
1871. Feb. 27	6 50 0± p.m.	Ibid.	= Mars or ♃	White	....	From 114°+29° to 150 +13

Length of Path.	Direction or Apparent Radiant-point.	Appearance; Remarks.	Observer.
28°	$T_{2,3}$. August to September, radiant in Pisces (?).	Left a very bright streak 8° long for 3 seconds.	G. L. Tupman. (Observations of shooting-stars, 1869–71.)
5°	Scheat (δ) Aquarii; much foreshortened near its radiant-point.	A very fine meteor with train ...	Id.
42°	N_1 11 or T 45	Nucleus with a short train	Id.
20°	Scheat, or Norma Aquariid (Ξ_1?)	A beautiful meteor; left no streak	Id.
14°	Q G (γ Aquila) 294+3	Close to the horizon	Id.
23°	Perseïd	Exploded two thirds of the way along its course, leaving there a lenticular cloud of red and yellow light.	Id.
9°	Perseïd		Id.
20°	Q G (γ Aquilæ) (gamma Aquilid)	A fine meteor with a train of sparks.	Id.
7°	Perseïd	Very bright streak. Twelve Perseïds in one hour; full moon. [The same rate of frequency also on the 11th, A.M.]	Id.
7°	T_1 or T_2 Pegasid	Meteor with train	Id.
21°	T 65 (Psalterium or Cetus) ...	Left a bright streak	Id.
28°	Perseïd		Id.
25°	Perseïd?	Left a streak	Id.
19°	T 57=T_3? (δ Piscium)		Id.
32°		Meteor with bright train	Id.
25°	T 57 (T_3?) (δ Piscium)	Left a very bright streak	Id.
40°	Geminid ...	Meteor seen by other observers; extremely large and brilliant. The streak remained 10^m, and a nucleus or cloud of it at 330−26 remained in sight 30^m or 40^m, drifting to 347−27, where it disappeared, being then 5° in diameter.	Id.
43°	Geminid		Id.
20°	Geminid	A very fine meteor	Id.
10°	Geminid	Meteor with train	Id.
37°		Position accurate	Id.

Date.	Hour, approx. G. M. T.	Place of Observation.	Apparent Magnitude, as per Stars &c.	Colour.	Duration.	Apparent Path.
1871.	h m s					
Aug. 19	2 0 a.m.	Queenstown (Ireland).	= Mars or ♃	White	2 secs.; slow..	$\alpha=$ $\delta=$ From 349° +47° to 9 +30
21	1 31 a.m.	Ibid.	= ♀	White	0·5 sec.; swift	From 30° +89° to 240 +78
Sept. 7	11 16 p.m.	Near Lisbon (Portugal).	= Mars or ♃	White	1·5 sec.; very slow.	From 50° +33° to 50 +23
8	0 36 a.m.	Ibid.	= Mars or ♃	White	1 sec.; very swift.	From 24° +28° to 337 +48
16	2 11 a.m.	Ibid.	= Mars or ♃	White	0·3 sec.; very swift.	From 33° +19° to 15 +18
16	2 28 a.m.	Ibid.	= ♀	White	0·3 sec.; very swift.	From 67° − 9° to 75 −23
16	2 47 0±	Ibid.	= Mars or ♃	White	0·5 second ...	From 38° +65° to 330 +74
1872.						
Dec. 12	4 53 p.m. (Washington mean time.)	Kentucky, U. S..	Very large	[White; Marion City, Kentucky.]	[Rapid; Ibid.]	From altitude 40°. 15° E. of S. to about altitude 10° S.S.E.
1873.						
Feb. 14	A little after 6 p.m. (Washington mean time.)	Newhaven, Connecticut, U. S.	Less bright than the planet Venus appeared.	Foremost nucleus green; the following one yellowish.	....	First appeared near the planet Venus, and shot to a direction N. 64° W., altitude about 15°.
Aug. 8	0 14 52 a.m.	Royal Observatory, Greenwich.	= ♃	White	1 second	Passed below η Andromedæ.
Sept. 9	10 5 p.m.	Ackworth, Somersetshire.	Brighter than Venus, even in moonlight.	Yellow	0·75 second ...	From altitude about 49°, 53° E. from S. to altitude 10°, 42° E. from S.

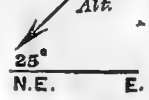
Length of Path.	Direction or Apparent Radiant-point.	Appearance; Remarks.	Observer.
22°	B_3 (?) Draconid	Meteor with train 5° long........	G. L. Tupman. (Observations of shooting-stars, 1869–71.)
13°	Perseïd	Left a bright streak	Id.
....	Perseïd? ($A_{12, 13, 14}$ and $A_{10, 11}$; 40+60 to 60+55).	Meteor with train	Id.
40°	....	Accurate observation. Left a streak 20° long.	Id.
14°	[R T ?]...........................	Left a streak 3° long for 3 secs...	Id.
16°	[R T ?]...........................	Left a very bright streak	Id.
23°	R T (75+25, max. Sept. 8–10).	Left a streak 10° long for 3 secs..	Id.
About 30° ...	Towards the east of south, inclined about 60° to the horizon, N.N.W. to S.S.E.	End of course and explosion seen through a southern window; no report heard. [At Marion City white; altitude 45° N.W. or N.N.W.; at first inclined, then immediately angular to the horizon. Smoke-cloud for several minutes; broke into parts. Report heard at George Town, Kentucky. At Lixington, from 30° W. to a point S.W. of the zenith, a loud report heard in 5^m.] [Meteor's true path from altitude about 30° or 60° N.W. to S.E., exploding about 20 miles over a point in the direction of the district of Lebanon, Kentucky.—H. A. Newton.]	D. Kirkwood. [Account by H. A. Newton, in 'American Journal of Science' for April 1873.]
10° while in sight.	Inclined northwards and downwards.	A smaller bright green nucleus in front, followed by a larger yellowish one. The principal nucleus also gave out some sparks. [As seen by Mr. Middleton, at New Britain, the meteor divided into two large balls and several smaller ones, which disappeared while the two large ones passed on.]	William C. Wood. [Reported by H. A. Newton; Ibid.]
8°	Perseïd	Left a streak	— Schultz.
....	70° from horizontal, thus— 	Position by measurement of window-top and distant tree-tops between which its course appeared; end perhaps observed, but beginning not seen. No sparks or streak on its course were visible through the closed window-pane.	E. Worsdell. (Communicated by J. E. Clark.)

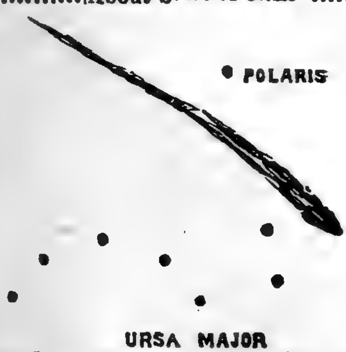
Date.	Hour, approx. G. M. T.	Place of Observation.	Apparent Magnitude, as per Stars &c.	Colour.	Duration.	Apparent Path.
1873. Sept. 15	h m s 8 55 p.m.	Ackworth, Somersetshire.	Slightly > ♀	White	1·5 second ...	From altitude 43° to altitude 20°, due west.
23	About 4 30 a.m. (local time).	Thirteen miles S. of Mooltan, India; on Shujabad road, 12 miles from Shujabad.	Multiple meteor, with many large and small nuclei.	All the nuclei brilliant palish green with red trains.	Advanced steadily but moved slowly.	First came into view at about altitude 15° due west; crossed the meridian at altitude about 60°, passed close under Orion, and proceeded to a point in the east as nearly as possible opposite to that at which it first appeared.
Oct. 14	7 15 p.m.	Weston-super-Mare, Somersetshire.	= ♀	White	2 seconds......	$\alpha=$ $\delta=$ From 18°+39° to 27 +27
17	Evening ...	Crowborough Beacon (Sussex).	....	....	....	....

Length of Path.	Direction or Apparent Radiant-point.	Appearance; Remarks.	Observer.
23°	↓	Left a slight streak..................	J. Neale and other observers. (Communicated by J. E. Clark.)
[About 140° or 150°.]	[Nearly due W. to E.]	First observed as a bright star rising slantingly; burst almost immediately like a rocket without scattering to any extent, and increasing continuously from the first in brightness, long before reaching its mid course, lit up the whole country with a greenish light. Twenty or more fragments were visible, all greenish, moving in parallel courses, the two or three largest in the centre leading. Each nucleus left a red train, forming together a huge band across the sky that remained bright for some time, and at last broke up into an irregular heavy line and into small detached clouds, which only disappeared upwards of an hour afterwards in the rays of the rising sun. Three and a half minutes after the disappearance of the meteor, a loud report followed, as of many distant cannons, that shook the ground and rolled on in reverberations for some time until it died away like distant thunder. Many were awakened by the report; and the meteor was seen at Shujabad, but no accurate accounts of its appearance could be obtained there.	G. Yates. ('Astronomical Register,' March 1874.)
....	Fell vertically; undetermined radiant-point.	Another meteor, almost as bright, followed it in the same part of the sky at 7^h 18^m P.M., and another was seen at 10^h 30^m P.M. by other observers.	T. H. Waller.
....	....	During the evening a number of small meteors were observed. 'Meteorological Journal for 1873,' by C. L. Prince.	

Date.	Hour, approx. G. M. T.	Place of Observation.	Apparent Magnitude, as per Stars &c.	Colour.	Duration.	Apparent Path.
1873. Oct. 18	h m s 0 15 a.m.	Royal Observatory, Greenwich.	= ♃	White	0·5 second; very swift.	$\alpha=$ $\delta=$ From 165°+68° to 210 +56
18	About 8 30 p.m.	Boltsburn (Durham).	Meteor of considerable brilliancy.			In the north-west part of the sky, commencing at altitude about 40°.
18	11 5 p.m.	Edgbaston, Birmingham.	= ♀	Reddish	2 seconds	$\alpha=$ $\delta=$ From 37°+36° to 1 +24
26	About 8 20 p.m. Time uncertain; "by guess only."	Thruxton (Hereford).	Very large and bright.	Flash of light intensely white.	Streamed across the sky.	Passed while in sight from ξ Persei above Capella (in altitude), and disappeared in Lynx.
26	9 51 p.m.	Royal Observatory, Greenwich.	Probably very large			Apparent position of the streak from η Cephei to a point a few degrees to the left of β Draconis.
30	0 20 a.m.	Regent's Park, London.	Larger than any star.	Yellow		From altitude 12°, S.S.W. to W., to altitude 2½°, S.S.W. to W.
Nov. 4	4 56 p.m.	Mattishall, Dereham (Norfolk).	A bright meteor	Pale green		In the E.N.E.
11	7 19 25	Royal Observatory, Greenwich.	♃ ×4	Bluish white.	1·5 second	From about 20° above the Pleiades; fell towards the horizon at an angle of 40° to the right.
23	About 6 30 p.m.	Birmingham	Very bright meteor			From altitude 60° W.S.W. to altitude 45° a little W. of S.
23	Evening	Crowborough Beacon (Sussex).				
Dec. 3	7 0 p.m.	Ibid.				

Length of Path.	Direction or Apparent Radiant-point.	Appearance; Remarks.	Observer.
25°	Accurately parallel to ϵ, ζ Ursæ Majoris.	Left a streak	G. L. Tupman.
	Shot downwards	Left a streak of very red light for 9 or 10 seconds.	J. Curry. ('Nature,' Nov. 6th, 1873.)
30°	Radiant near Castor and Pollux (Schiaparelli, No. 37).	Brightened suddenly just below β Andromedæ, and there left a ruddy streak for 1 second.	T. H. Waller.
		A lightning-like flash drew attention to the meteor, which was extremely bright for two thirds of its flight, leaving a train of sparks; but in the remaining third of its course it only showed its own single expiring light. Two telescopic meteors, apparently from the same radiant-point, were observed later in the evening in Cepheus.	F. T. S. ('Nature,' Nov. 6th, 1873.)
		A brilliant flash of bluish-white light, at first supposed to be lightning. On looking immediately to the sky, the trail of a meteor was observed, which was very bright, and remained visible two seconds.	W. C. Nash.
9° or 10°	Fell quite vertically	Disappeared behind some trees. Left no streak.	H. S. Wallis. (Communicated by G. J. Symons.)
	Fell vertically		J. M. Duport. (Communicated by G. J. Symons.)
30°		Left a streak and sparks on its course.	— Schultz.
		Burst into coloured fragments. Notice attracted by the light.	F. J. Waller. (Communicated by T. H. Waller.)
		One large meteor and many small ones were observed on this evening.	C. L. Prince. ('Meteorological Journal' for 1873.)
		A brilliant meteor was visible to the eastward.	C. L. Prince. ('Meteorological Journal' for 1873.)

Date.	Hour, approx. G. M. T.	Place of Observation.	Apparent Magnitude, as per Stars &c.	Colour.	Duration.	Apparent Path.
1873. Dec. 11	h m s 10 38 p.m.	Newcastle-on-Tyne.	=♃	Bright pale green.	1·2 second ...	First appeared at γ Cancri. Disappeared with a small spark projected to left.
11	10 39 p.m.	Glasgow (Scotland).	=♃	White or yellow.	1·5 second ...	From altitude 12° to altitude 3° or 4°.
1874. Jan. 7	About 5 0 p.m.	Near Colchester (Essex).	=♀	Just the colour and appearance of Venus.	3 or 4 seconds	In the S.S.W. part of the sky. (Approximate position and bearings only.)
7	5 7 p.m.	Ventnor (Isle of Wight).	About one fourth apparent diameter of the full moon.	Pale greenish yellow.	Very slow motion; 5 or 6 seconds while in sight.	In the west, moving at an altitude of about 40°. Path dipping at an angle of about 5° towards the north.
Feb. 28	About 7 0 p.m.	Sevenoaks (Kent).	About the second magnitude of large fireballs [*i. e.* about=♀, or brighter].	Pale yellow; uneven edges of the train red.	Much slower than usual with shooting-stars.	....
Apr. 11	9 18 p.m.	Bristol	=♃	....	2 seconds	$\alpha=$ $\delta=$ From 242° +47° to 278 +50 About E.N.E. to N.E., thus— 

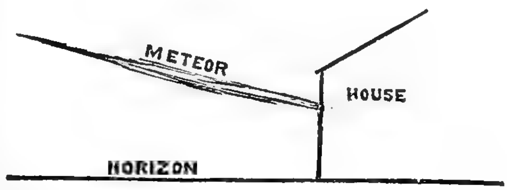
Length of Path.	Direction or Apparent Radiant-point.	Appearance; Remarks.	Observer.
14°	Directed from 2° left of Castor (Geminid). 	At first small, but uniformly bright in the last two thirds of its flight. Left no streak.	A. S. Herschel.
About 8°......	Fell vertically from the direction of iota Geminorum (Geminid; identical with the last). 	Followed by a short train	R. McClure.
About 15° ...	Fell nearly straight down, inclining a little towards the south-west.	.... 	J. Gripper. (Communicated by H. Corder.)
....	.... 	Nucleus globular; burst at last into a shower of various-coloured sparks. Seen in dusk or afterglow; sky cloudless. A bright light first drew attention to the meteor.	T. Perkins.
....	About S.W. to N.E. .... 	A beautiful meteor, with a long train of the same colour as the head. Moved majestically across the sky, which was very clear. No other meteor visible in a watch of some length at the same hour.	W. E. Buck.
About 24° ...	Radiant near β Boötis (G 36 = 223 + 40).	Nucleus emitted numerous sparks while in motion.	W. F. Denning. ('Nature,' April 16th, 1874.)

Date.	Hour, approx. G. M. T.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position.
1874. May 12	h m s Shortly before 11 p.m.	Bristol	Large fireball; shone as bright as the full moon.	....	Moved rapidly	....
19	0 50 a.m.	Off Holyhead ...	Elongated oval disk: major diameter equal apparent diameter of the sun.	Spread a soft green light on all objects throughout its course.	At first stationary for 2 or 3 seconds, then moved slowly northwards.	Formed near Antares. Disappeared in the Great Bear.
June 9	0 2 59 a.m.	Camden Square, London, N.W.	2 × ♃	Silvery white..	....	N. 32° E., altitude 18°, to N. 34° E., altitude 12°. 
17	9 15 p.m. Karlsruhe time. [G. M. T. 8^h 40^m.]	Heidelberg, Germany.	Very bright	....	2·5 seconds or more.	α= δ= From 278° +35° to 285 0
24	0 55 a.m.	Ibid...............	= ♃	White	0·75 second ...	α= δ= From 197° +56° to 172 +55
24	11 55 p.m.	Regent's Park, London.	Large fireball	....	....	From considerably S.E. of the zenith; ended about midway between Cassiopeia and Andromeda.
July 1	10 45 p.m.	Ibid...............	Large meteor	Looked very much like a red-hot cinder.	Moved slowly	Disappeared about 3½° above α Capricorni.
6	10 30 p.m.	Bridport, Dorsetshire.	Brilliant; a vividly bright meteor.	....	....	α= δ= From 235° +55° to 101 +64 Approximate apparent path.
13	0 29 a.m.	Penge	= ♃	....	Quick	From near ε Tarandi to α=156°, δ=+65½°.

Length of Path.	Direction or Radiant-point.	Appearance; Remarks, &c.	Observer.
Shot some distance across the heavens.	In a north-westerly direction...	A very brilliant meteor; burst at disappearance into beautiful coruscations of coloured light.	The 'Bristol Daily Post,' May 13th, 1874.
....	....	A short time before it disappeared, six sparks as large as Jupiter were discharged from its southern end. A most brilliant meteor, followed by a crackling sound (?).	William W. Kiddle.
....	....	....	G. J. Symons.
About 35° ...	....	Left no streak...............	Communicated by J. E. Clark.
16°	....	Left no streak; attention called to the appearance by its brightness.	J. E. Clark.
....	....	The light was intense, and the flash lit up the sky.	Communicated by T. Crumplen.
....	Moved apparently from the same radiant-point as the last meteor.	Extremely bright for the first instant, then rapidly disappeared. A view of the end only caught as the meteor disappeared.	T. Crumplen.
5°	Radiant 72, Greg; (Q_3)........	....	Communicated by J. E. Clark.
....	Head varied in brightness; disappeared suddenly; left a bright green or blue streak on its whole course of irregular brightness, parts remaining 1 second.	....	T. W. Backhouse.

Date.	Hour, Approx. G. M. T.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position.
1874. July 16	h m s About 0 45 a.m.	Lewisham, Kent	Magnificent fireball	....	Moderate speed.	Passed some degrees (4° to 10°) south of Altair. View of the end of its course lost behind houses.
27	8 15 p.m. Paris time.	Toulon, France...	Shone brighter than the full moon. Apparent diameter of the disk one fourth that of the full moon.	Nucleus a fine yellow colour; train bright red.	Moved rapidly, traversing its whole course in about one minute thirty seconds.	Commenced close to the horizon in the north-west; passed through the south-west part of the sky at an altitude of about 60° or 65°, and disappeared over the sea at an altitude of about 15° above the south-east horizon.
27	8 50 p.m. Paris time.	Versailles, France	Apparent disk about one fourth that of the full moon, and much inferior to the full moon in brightness.	....	Three or four seconds.	Appeared in the constellation Virgo.
? 27	10 35 p.m.	Buntingford, Herts.	Nucleus with sensible disk.	White	About 1 sec...	From close to Arcturus nearly to the horizon.
28	About 8 39 p.m.	Regent's Park, London.	Very large and bright meteor. Apparent size of disk 4 in. ×3 in.	The forward half like a magnesium light; the other half much the colour of burning sodium.	Travelled very slowly; in sight about 3 seconds.	Fell in a curve from a point due W.S.W. to a point in the N.N.W.

Length of Path.	Direction or Radiant-point.	Appearance; Remarks, &c.	Observer.
Very long course.	East to west, as in the accompanying sketch.	Streamed majestically along, becoming brighter and brighter, and the streak growing broader and broader.	H. W. Jackson.



Length of Path.	Direction or Radiant-point.	Appearance; Remarks, &c.	Observer.
Almost from horizon to horizon.	N.W. to S.E., following nearly the course of the ecliptic, but in a direction opposite to that of the daily motion of the heavens.	Nucleus with a broad train like that of a comet, 12° or 15° long and 4° or 5° wide, in its track, along which were scattered small sparks which disappeared slowly.	M. Lecourgeon. (Comptes Rendus, 1874, August 3rd.)
About 15° ...	The direction of its course was horizontal, from S.E. to N.W.	....	M. Martin de Brettes. (Ibid.)
About 20° ...	Fell vertically; probably a "Cygnid."	....	R. P. Greg.
....	....	Left a long dark trail on its path rather wider than the head; yellow smoke-colour at the base, shading to deep black, and rather tapering than speading out towards the end. Seen in strong evening twilight. Sky very clear and bright.	William Sowerby. ('The Times,' July 31st, 1874.)

Date.	Hour, approx. G. M. T.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position.
1874. Aug. 1	h m s About 10 50 p.m.	Corbridge, near Hexham, Northumberland.	Large ball of fire with many smaller ones in its train.	Meteor-heads green on a large bar-like line of rich blood-red light.	....	Fell from the western edge of a dark cloud over Hexham and Dilston directly to the earth, which it seemed to strike in the region of the north Tyne, just above its confluence with the south Tyne.
3	8 30 p.m.	Roker, near Sunderland, Durham.	Large meteor	....	....	About halfway between the zenith and the west horizon.
10	11 53 p.m.	Birmingham ...	=1st mag.*, then >Venus. Elongated nucleus $\frac{3}{8} \times \frac{1}{4}$ apparent diameter of the full moon.	Blue-white, then red.	6 seconds......	$\alpha=$ $\delta=$ From 260°+18° to 216 +32 Expanded to an oval nucleus in passing across Corona, dropping some red fragments between α and β, and exploded near β Coronæ.
10	11 53 50 p.m.	Newcastle-on-Tyne.	=Venus	Orange-yellow, then bright green with red train.	2·8 seconds while in sight.	$\alpha=$ $\delta=$ From 287°−17° to 275 −17

Some additions have been made, of which the principal is a long list of the largest meteors described in the recently published catalogue of shooting-stars observed in the Mediterranean by Captain Tupman. An attempt was made in selecting these large meteors from the list to arrange them under their most obvious radiant-points, and to determine, if possible, from the results the dates of greatest intensity of the showers to which they respectively belonged. The exact descriptions of their apparent paths is unusually favourable to such a preliminary course of treatment of the general catalogue; but the indications expected to be obtained of the occurrence of a period of maximum intensity of any already established or newly traceable star-shower among their apparent courses, have proved unproductive of any material results. The dates of their appearance are throughout inconstant; and where they nearly synchronize, the directions of the meteors' apparent

Length of Path.	Direction or Radiant-point.	Appearance; Remarks, &c.	Observer.
....	....	Principal nucleus followed by half a dozen pear-shaped fireballs; illuminated the surrounding district for an instant as if by the electric light.	'Newcastle Daily Chronicle,' Monday, Aug. 3rd, 1874.
....	From N. to S.	....	Communicated by G. Iliff.
Very long path	Radiant (?) in Aquarius; course deflected downwards at β Coronæ to ϵ Boötis, where it finally collapsed.	Besides red fragments, the meteor evolved some white smoke-wreaths 4° or 5° long, as it passed across Corona. After explosion there, it reappeared as a first magnitude red star, pursuing its course further on a deflected line.	W. H. Wood.
About 12° while in sight.	Horizontally, thus—	Imperfect view of commencement. Some degrees before disappearance, nucleus expanded with strong intermittent green light and fragments on a train of red sparks. Disappeared suddenly at greatest brightness. Left no streak.	A. S. Herschel.

courses prove them to have belonged to different meteor-systems, or at least not simultaneously to any one of the hitherto established systems of occasional shooting-stars. Among the sixty-four bolides of the list, known radiant-points are assigned to forty-eight (or 75 per cent.), without any signs of recurrence on particular days, or of any such shower exhibiting an unusual number of large meteors on a certain date. The possible existence of meteor-showers consisting principally of large meteors is therefore not discernible from this fireball-list; but as it only extends to three years' observations, a wider discussion of the question, if it were possible from the comparatively small number of bolides of which the apparent paths have been accurately observed, will be necessary to determine if no such meteor-showers exist.

The list of radiant-points obtained from his observations by Captain Tupman is here extracted from his catalogue, accompanied by an illustrative

Catalogue of Radiant-points observed in the Mediterranean, in the years 1869, 1870, and 1871, and comparison of the Positions with those of other observers. By G. L. Tupman*.

The columns of the catalogue require no other explanation than that the Zenith Horary Number, where given, has been obtained by multiplying the number of meteors counted per hour by the secant of the zenith-distance of the radiant. It represents the number that would probably have been counted by a single observer with the radiant in his zenith. The results of special observations of the great August stream are given in an Appendix to the Catalogue of Radiants, together with those of other observers.

No.	Date of Observation.	R.A. and Declination for 1830.	Zenith Horary Number.	(D.), Prof. Denza (Memorie, etc.). (H.), Dr. Heis. (N.), Prof. Neumayer. (S.), Dr. Schmidt. (A. S. H.), Prof. Herschel.	Mr. Greg's Numbers and Dr. Heis's Letters.	Dr. Schmidt (Athens), Astr. Nach. No. 1756.
1.	1870, January 2–7	$229^\circ+51^\circ$	$6\frac{1}{2}$	Masters, 1863, January 2 (A.M.), $238^\circ+46\frac{1}{2}^\circ$	4, K_{1-3}	
2.	1869, December 23–31	160+ 3	......	....	22	
	1870, January 8–10	165+ 4	......	....	S_1	
	January 11	173+ 9	......	....	S_2	
	February 3–10	175+16	......	(N.), February, $174^\circ+16^\circ$	....	March .... $162^\circ+24^\circ$
3.	1870, January 4	142+ 5				
	January 11	149+ 5	......	....	? 112	December ...... 145+16
4.	1870, January 4–31	180+35	......	Not accurate	8, ? M_2	
	February 3–10	180+35	......	Not accurate.		
5.	1870, January 5	185+15	......	....	22	
	January 11	173+ 9	......	....	$S_{1,2}$	March .... 162+24
	February 3–10	175+16	......	(N.), March, $174^\circ+16^\circ$.		
6.	1870, January 5, 11	210− 6				
	1869, February 13	202− 9				
	1870, March 2–3	200−10				
7.	1870, January 5	145−25	......	See 18.		
8.	1870, January 8–11	200+ 2	......	See 21	? 31	
	1869, February 13	205+ 4	......			
9.	1870, February 3–10	210+36	......	S. and Z., $209^\circ+25^\circ$	? 9, 15	
10.	1870, February 3–10	237+20				
	1869, February 13	237+13	......	Accurate ? 19, 27	? 15	

* Monthly Notices of the Royal Astronomical Society, vol. xxxiii. p. 300. Reprinted in this Report from the Catalogue of Captain Tupman's Observations, published this year, with two Plates, under the superintendence of the Luminous Meteor Committee of the British Association.

11.	1870, February 3–10	198−22	......	See 17.			
	1869, March 19	202−28	......				
12.	1870, February 3–10	219−23					
	1869, February 17	218−13					
13.	1870, February 8–10	180−20					
14.	1870, February 10	290−12	......	Not accurate	41		
15.	1869, February 13	230− 7	......	Suspected	40		
16.	1869, February 13	260± 0	......	Suspected ; see 21.			
17.	1869, February 22	217−41	......	Suspected.			
	March 11	205−33	......	Suspected.			
	March 19	202−28	......	Suspected. ? 11.			
18.	1870, March 1	142−25	......	Suspected. ? 7.			
19.	1870, March 2–3	247+18	......	See 10, 27	? 51		
	1869, March 7	244+15	11				
20.	1870, March 2–3	260+19	......	....	? 38		
21.	1869, March 14–15	266+ 6					
22.	1870, March 2–3	209+18	......	....	$S_{5, 6}$		
23.	1870, March 2–3	236−13					
	1869, March 7	233−18	9	....	? 40		
24.	1870, March 2–3	193+ 1	......	(H.), April, 194°+5°	31		
	1869, March 19	194+10	......		? S_2		
25.	1870, March 2–3	240+39					
26.	1870, March 7	186− 9					
27.	1869, March 7	241+ 8	......	Suspected	30		
	1870, March 7	246± 0	......	See 10, 19, 31.			
28.	1870, March 7	270−22	......	After 3 A.M. only.			
29.	1870, April 25	273−30	......	Suspected.			
30.	1870, April 27	286−27					
31.	1870, April 27	256− 2	......	Accurate	? 30		
32.	1870, April 27–28	230+ 5	......	B.A. Atlas confirmed	? 40		
33.	1871, April 29	329− 2	30	Fairly accurate.			
	1870, April 30	325− 3	15				
	1870, May 2–3	325− 2½	21	Fine shower, May 2.			
34.	1870, May 2	285+12	......	(H.), June 1–30, 292°+15°	? 56 ? W	July 5–25	278+13
35.	1870, May 2	298+ 5	......	....	? 57, 63	June	313+12
	June 28	305+ 9	......	(N.), 305°+5°	? W	July 5–28	314+10
36.	1870, June 28	293−11	......	(S.), confirmed	....	June	293−11
	June 29	284−16	......	(N.), June, July, 263°−15°	....	July 18–31 ...	287−21
	July 1	287−13	......	....	....	June	282− 3
	July 6	277−10	......	Rough.			
37.	1870, June 28	305− 7	......	(N.), confirmed (305°−6°)	....	July 5–25	301− 5
	July 22	306− 8	......	(S.), confirmed	....	August 1–31 ...	306− 8

Catalogue of Radiant-points (*continued*).

No.	Date of Observation.	R.A. and Declination for 1830.	Zenith Horary Number.	(D.), Prof. Denza (Memorie, etc.). (H.), Dr. Heis. (N.), Prof. Neumayer. (S.), Dr. Schmidt. (A. S. H.), Prof. Herschel.	Mr. Greg's Numbers and Dr. Heis's Letters.	Dr. Schmidt (Athens), Astr. Nach. No. 1756.
38.	1870, June 28	338°+13°	......	B.A. Atlas confirmed	67	June ... 335°+10°
	July 1–6	337+ 1	......	....	....	July 5–28 ... 335+ 7 July 20–31 ... 334+ 1
39.	1870, June 29–30	280+29	......	B.A. Atlas confirmed	56	June ... 284+38
40.	1870, July 1	235+ 0				
41.	1870, July 1	N. Pole				
42.	1870, July 8	316+22	......	....	T_1. ? 80	June ... 319+32 July 5–30 ... 317+32
43.	1870, July 27 July 28	340−14 340−19	....	Accurate. (N.), August to September, 341° −6°, 337°−10°. Weiss, 1869, August 11–13, 338½°−5°	130	July 20–31 ... 333−14 July 20–31 ... 340− 8 August 1–31... 344−11 August 1–12... 345− 7
44.	1870, July 21 July 28	320− 4 326−13	....	....	130	July 25–31 ... 324− 6 August 1–31... 328−22 August 3–31... 331−13
45.	1870, July 27	7+32	7½	(D.), 1869, August 10, 0°+28°	84	August 1–31... 11+30
	August 23	0+33	......	(H.), August 1–31, 11°+30° (?)	....	September ... 3+30
46.	1870, July 27 to August 28	Perseus	......	See Appendix	85. A_{9-12}	
47.	1870, July 29	45−21	......	Just before daylight	....	August ... 55−18
48.	1869, August 4 1870, August 22 August 28	41+34 39+28 39+28	....	Schiaparelli, August 10, 41°+34° Weiss, 1869, August 11, 46½°+23½° August 12, 41½°+24°. (D.), 1869, August 10, 48°+19°	82 132	August 3–12... 54+28
49.	1869, August 6 August 18	0+17½ 7+13	....	(H.), September, 1°+11° (H.), October, 3°+11°	88 T_3	July ... 0+17 August 1–31... 13+ 9 Sept. 3–10 ... 17+ 9
50.	1871, August 13	310+58	5½	(H.), August 15–31, 306°+59°. (D.), August 10–11, 304°+41°	? 68 B_6	August 4–9 ... 304+60 September ... 309+67
51.	1870, August	340+33	......	(D.), 1869, August 11, 350°+24°	76	July ... 345+25 August 1–15... 338+30 October ... 345+30
52.	1870, August 22	300+85	......	(D.), 1869, August 10, 239°+75°. August 11, 298°+89°	75 N_{13-15}*	

* Misprinted H_{13-15} in the original list.

53.	1870, August 22	82+67	......	Suspected. Weiss, 1869, August 11, 77°+54°	? 97		
54.	1870, August 23	334+48	5	Accurate. B.A. Atlas, August 7 to September 30, 335°+52°. Weiss, 1869, August 12–13, 345°+50°	96 ? B_2	August 7–31...	347+51
						September ...	354+43
						October (end)	340+58
55.	1870, August 23	295+28	3	Accurate.			
	August 23	302+21	......	Subradiant	? T_1	? August	311+35
56.	1870, August 23	297+ 2	......	Weiss, 1869, August 11–13, 298°+8½°. (D.), 1869, August 10–11, 296°+6°	? 63		
						July	7+ 4
57.	1871, August 20–25	358+ 6	......	....	T_3. ? 88	August	3+ 1
						Sept. 3–30 ...	0+ 1
58.	1871, August 20–25	280+58	......	B.A. Atlas, July to August, 280°+55°. (D.), 1869, August 11, 277°+54°	? 71, B_7	September ...	290+58
59.	1871, August 20–25	264+64	......	....	? 83	? August 4–11	252+53
60.	1871, August 20–25	110+32	......	Suspected.			
61.	1871, August 20–25	5+49	......	Declination accurate. ? 38	78. ? 84	October 22–28	5+53
62.	1871, August 20–25	23+36	......	Accurate. Denza, 1868–69, August 8–13, 15° +34°	98. ? P_1	? August	23+20
63.	1871, August 20–25	330+12	......	....	67. ? T_2	August	338+17
						August	325+ 1
64.	1870, August 29	70+31	......	See 72, 83	? 94, A_{16}	September ...	70+23
	1871, September 7–15	66+40	......			October 10–27	71+31
						August	53+ 1
65.	1871, August 20–25	53+ 1	......	(S.), confirmed	....	August 3–12...	55+ 7
						October	50+ 2
66.	1870, August 29	75+45	......	(D.), 1869, August 10, 61°+43°	? 100		
67.	1870, August 31	85−15	......	See 80, 86	....	? October 18–27	87− 2
68.	1870, September 5	42+55	......	Accurate. Meteors small and swift. ? Subradiant to great Perseus stream. See 71, 74.	A_{13} ? 85		
69.	1870, September 5	48+41	......	Subradiant suspected. See 48	$R_{1, 2}$		
70.	1870, September 6	35+45	......	Another subradiant. (D.), 1869, August 10, 37°+46°.			
71.	1870, September 6	{ 25 / 40 } +60	......	? 68	92, $A_{12, 13}$		
72.	1870, August 29	(78+23)	......			September ...	70+32
	1869, September 8–10	78+23	16	See 64, 75, 79, 83	104	October 10–27	71+31
	1871, September 22	75+15	......			October 10–27	79+13
73.	1871, September 7–15	345+13	......	(H.), September 1–15, 343°+10°	89, T_2	? Sept. 1–10...	337+20
74.	1871, September 7–15	{ 54 / 64 } +56	......	? 68. Weiss, 1869, August 13, 70°+53°	97, A_{15}		
75.	1869, September 13	68+ 5	8	Accurate	....	August 3–12...	55+ 7
	September 14	62+ 9	5	? 72	....	? Sept. 3–30...	51+14
	September 15	65+ 3	5	....	....	October 10–22	62+ 6

Catalogue of Radiant-points (*continued*).

No.	Date of Observation.	R.A. and Declination for 1830.	Zenith Horary Number.	(D.), Prof. Denza (Memorie, etc.). (H.), Dr. Heis. (N.), Prof. Neumayer. (S.), Dr. Schmidt. (A. S. H.), Prof. Herschel.	Mr. Greg's Numbers and Dr. Heis's Letters.	Dr. Schmidt (Athens), Astr. Nach. No. 1756.
76.	1869, September 13	68° − 5°	......	Subradiant to 75.		
	October 12	76 −10	......	Accurate. See 80, 89	....	? October 18–27 87° − 2°
	October 13	77 −10				
77.	1871, September 22	345 +61	......	? 54	90, 96	August 7–31... 347+51
78.	1869, October 5–6	54 −14	......	(N.), October, 50° −4°	....	August ...... 55−18 September ... 55− 6
79.	1869, October 5–6	91 + 9	10			
	October 8	86 + 6	6	Subradiants	....	September ... 82+ 6
	October 10	90 +12	9			
	October 12	89 +16½	......	Accurate.		
	October 13	87½ +14	......	Accurate	104	
	October 14	87 ± 0	......	Subradiant well marked	....	? November ... 79+ 5
	October 14	97 ∓10	......	Subradiant.		
	1869, October 15–16	89 +16	12	Accurate.		
	October 17	91 +18	......	Good. (A. S. H.), 1864, October 18, 90°+16°	....	October 18–27 93+17
80.	1869, October 5–7	85 − 2	6½			
	October 12	90 −10	......	? Subradiant 79	....	October 18–27 87− 2
	October 14	87 ± 0	......			
81.	1869, October 7	39 + 3	6			
	October 13	43 +11	......	Very accurate. See 83, 93.		
	October 14	44 + 4	......	Good. (H.), December 10–21, 41°+12°	? 87	? October...... 50+ 2
82.	1869, October 8	107 +12				
	October 14	110 + 6	......	See 87	? 105	October ...... 108+12 November ... 113+14
	November 7	101 + 7	4	Good.		
83.	1869, October 8	77 +37	6	(H.), 72°+44°.		
	October 12	68 +25	......	Rough. See 72	? 100	September ... 70+32
	October 13	77 +30	......	Accurate	A_{16}	October 10–27 71+31
84.	1869, October 10	47 − 6	8½	(N.), October, 50° −4°	....	Sept., mean of three ...... 43− 6½
85.	1869, October 11	150 +13	13	....	....	? October...... 140+23
86.	1869, October 11	93 −24	......	See 67, 80.		
	October 12	93 −18	......			

87.	1869, October 11	107 − $2\frac{1}{2}$	......	See 82	....	? October	115 − 10
	October 16	101 ± 0	......				
88.	1869, October 11	128 +20	......	Suspected	....	? October	140 + 23
						? November	113 + 14
89.	1869, October 12	76 −10	......	Accurate	....	October 18–27	87 − 2
	October 13	77 −10	......	See 76, 80.			
90.	1869, October 12	105 +24	......	Birmingham, December, 107° +19°. See 82	105	December	102 + 19
						Dec. 10–21	111 + 27
91.	1869, October 13	58 +$10\frac{1}{2}$	......	Accurate.			
	November 7	50 +$14\frac{1}{2}$	9	Accurate. Rich shower with well-defined double radiant, 1872, November 1–3, 56° +24°	111 R_4	October 10–22	62 + 6
	November 9	52 +$12\frac{1}{2}$	8	Good.		October	50 + 2
	November 7	57 +$19\frac{1}{2}$	6	Accurate.		December	55 + 5
	November 9	59 +18	5	Good.		December	58 + 20
	November 10–12	53 +18	7	Accurate.			
92.	1869, October 15–16	86 +45	......	(A. S. H.), 1864, September 27, 85° +50°	100. ? A_{16}	November	82 + 45
93.	1869, October 13	28 +10	......	Accurate	....	? Oct. 19–27	33 + 21
94.	1869, November 3	30 +22	......	....	? 109	December	34 + 28
95.	1869, November 6	61 + 1	......	....	....	October 10–22	62 + 6
						December	55 + 5
96.	1869, November 6	57 − 9					
97.	1869, November 7	160 +40	......	Position estimated.			
98.	1869, November 7	$124\frac{1}{2}$ + $4\frac{1}{2}$	......	Accurate. Sharply defined	112	December	120 + 10
99.	1869, November 10–11	77 +10	3	....	....	October	79 + 13
						November	79 + 5
						December	73 + 4
100.	1869, November 13–14	151·0 + 21·5	......	'Monthly Notices,' vol. xxx. p. 29	115	Nov. 10–14	148 + 22
	1866, November 13–14	149·8 + 22·2	......	Equinox of dates	L	December	146 + 16
101.	1870, December 12	110 +40	......	Wood, 1866, 112° +34°. (H.), M_9 December, 112° +39°. (Bir.), December 12, 1867, 107° +19°	125 M_9	October	112 + 48
						January	105 + 44
102.	1869, December 23–27	130 +49	......	(H.), December 15–31, 137° +59°. January 1–15, 135° +57°	2	? December	130 + 30

Appendix to the Catalogue of Radiants, containing the Determinations of the great August Radiant in Perseus.

Date of Observation.	R.A. and Declination, 1850.	Z.H.N.	
1870, July 27–29	Perseus.		
1869, August 4	39° + 58°		
August 4	47·5 + 58·0		
1870, August 4	45 + 60	15	
August 5	54 + 54	10	
1869, August 6	47·5 + 48·0	...	Accurate. Subradiant.
1870, August 6	42 + 56	13	Accurate.
August 6	48 + 65		
August 7	46 + 61	31	Position estimated.
1869, August 8–10	50 + 56 42 + 64 50 + 63 47·5 + 58·0	26	
1870, August 8	45·0 + 59	95 :	R.A. accurate; 14 meteors counted in 9½ minutes at $15^h\ 20^m$.
August 9	42·0 + 57·5	60	Accurate.
1871, August 10	43·0 + 59·0 40·5 + 56·5	65	Accurate.
1869, August 11	50 + 56		
August 11	39 + 65		
August 11	47·5 + 59·0	20	Accurate.
1870, August 11	43·5 + 58·5	10	Full moon.
1871, August 11	40·5 + 57·5 40·5 + 56·0	13	Both accurate.
August 11	45 + 62		
1869, August 12–15	47·5 + 59·0	...	Sharply defined.
1871, August 12	46·0 + 58·4 40 : + 56·5	13	Accurate. Declination accurate.
August 13–18	Perseus.	...	Z.H.N.=10 on 13th.
1870, August 14–19	Perseus.	...	Poor 14th and 16th; rich 18th and 19th.
August 22	55 + 52	5	Accurate.
1871, August 20–25	55 + 57	...	Declination accurate.
1870, August 29	45 + 50		
August 29	75 + 45	...	No. 66.
September 5	40 45 + 55	...	Accurate. No. 68; ? branch stream.
1871, September 7–15	54 64 + 56	...	No. 74.

Other Determinations.

Authority.	Date.	Position.
Dr. Schmidt[1]	August 3–10	46° +55°
"	August 3–12	31 +55
"	August 3–12	50 +48
"	August 3–17	50 +62
"	August 3–11	56 +47
Dr. Heis[2]	July 16 to August 15	50 +51
"	July 1–15	41 +62
"	July 15–31	51 +55
"	August period	51 +55
"	August 15–31	35 +61
"	September 1–15	35 +63
"	September 16–30	44 +63
"	October 1–15	{51, 57} +61
Dr. E. Weiss[3]	1869, August 11	49·9 +55·6
"	August 12	49·5 +56·7
"	August 13	49·1 +61·6
"	August 11–13, mean of three.	73·1 +53·6
Professor Schiaparelli[4]	1866, August 10·7	41 +56
Professor Denza[4]	1868, August 10	44 +57
"	1869, August 10	44 +56·5
"	August 11	35 +60:
Professor Parnisetti[4]	1869, August 10	23 +57
"	August 10	61 +43
"	August 11	26 +57
Professor Lorenzoni[4]	1869, August 8–13	26 +62
"	August 8–13	58 +58
"	August 8–13	37 +46
Professor Serpieri[4]	1869, August 10	44 +56·5
Professor Tacchini[4]	1869, August 10	43·3 +56·2
"	August 10	42·5 +56·0
"	August 11	27·8 +62·0
At Lodi[4]	1869, August 10	43 +57
Professor Twining[1]	1869, August 10	45 +58

[1] Astronomische Nachrichten, No. 1756.
[2] Monthly Notices, vol. xxiv. p. 213; and B. A. Atlas for 1868.
[3] Beiträge zur Kenntniss der Sternschnuppen, 1870, Mai 19.
[4] Memorie (V. and VI.) sulle Stelle cadente. Torino, 1870?

map and planisphere of all the regions of the sky visible in the latitude of Greenwich. A description of these two plates and directions for their use is added from the pamphlet of Captain Tupman's observations, 500 copies of which were this year printed by the Meteor Committee of the British Association, and distributed under their directions to the principal Scientific Societies, directors of Astronomical Observatories, and leading observers of shooting-stars in this and other countries, from some of whom acknowledgments of its communication were received. Preliminary discussions of its list of meteor-tracks have already appeared in foreign journals ('Memorie della Societa degli Spettroscopisti Italiani,' May 1874), of which an abstract, when the memoir is received by the Committee, will be given in a future Report. The latest general list of radiant-points observed by Dr. J. F. Schmidt, of Athens, to which frequent allusion is made in Captain Tupman's list, and of which no copy has hitherto appeared in these Reports, is also appended here, to assist observers in reducing observations of occasional shooting-stars to the radiant-points of known meteor-showers. A general list including the two last-named, and accordingly, as far as such a compilation can be accomplished successfully, believed to be complete, is offered by Mr. Greg for the same purpose. From its comprehensiveness, embracing almost exhaustively all other radiant lists which have hitherto appeared, and adding to them many special references, it is believed that no fuller Table of the probably existing centres of meteoric radiation throughout the year can be used and consulted by observers, in the present largely developed state of this inquiry, as a standard catalogue for reducing, verifying, and recording their occasional notes of shooting-stars, and for identifying meteor-streams on occasions when their radiant-points can be independently observed and exactly or approximately ascertained. As intended, however, chiefly for observers in the northern hemisphere, several of the extremely southern radiant-points of Heis and Neumayer's list are for brevity not included in it.

DESCRIPTION OF THE PLATES.

Plate XV.

is a chart of the observed radiant-points, on an equidistant projection, with the North Pole in the centre.

The meridians and parallels are dotted at intervals of 2°.

The positions of the radiant-points are represented by the numbers in the first column of the Catalogue, enclosed in a circle, or in an irregular figure resulting from discordances in the determinations.

The graduations enable the observed tracks of meteors to be suitably projected upon tracings containing only those radiant-points proper to the season and above the horizon at the time of observation.

Plate XVI.

contains the projections of graduated great circles of the sphere crossing Plate XV. at intervals of 10° from the Pole, which occupies the centre.

The transparent tracing, prepared as described above, is superposed on Plate XVI., centre over centre, and turned round until the meteor-track is symmetrically situated between two of the curves seen through the tracing. All the radiant-points from which the meteor could possibly proceed can then be found immediately by prolonging the track backwards along the curves.

The proper curve on Plate XVI. can be selected and transferred to the tracing to represent the observer's horizon.—[G. L. T.]

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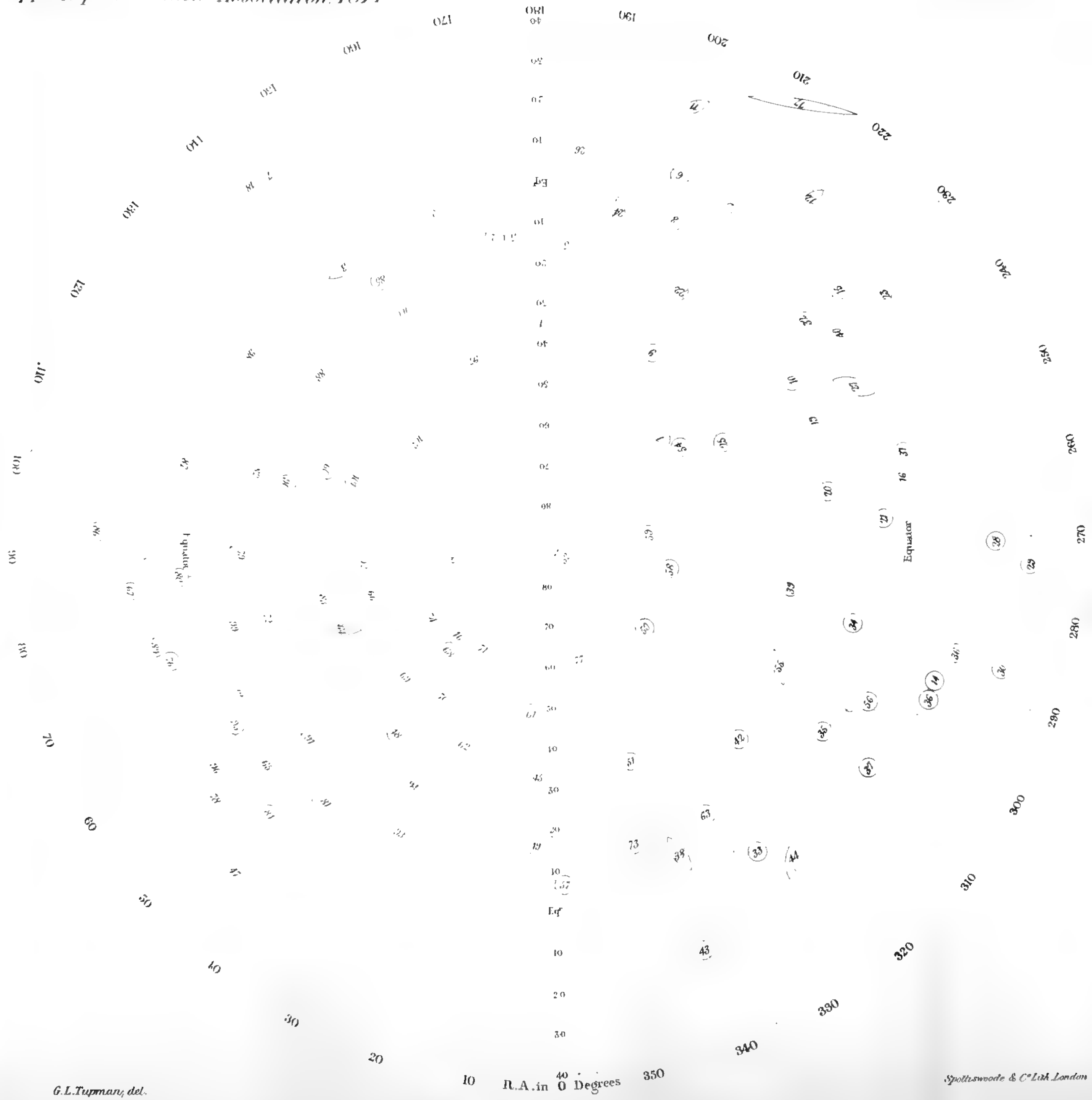
...	26— 6
...	9—15



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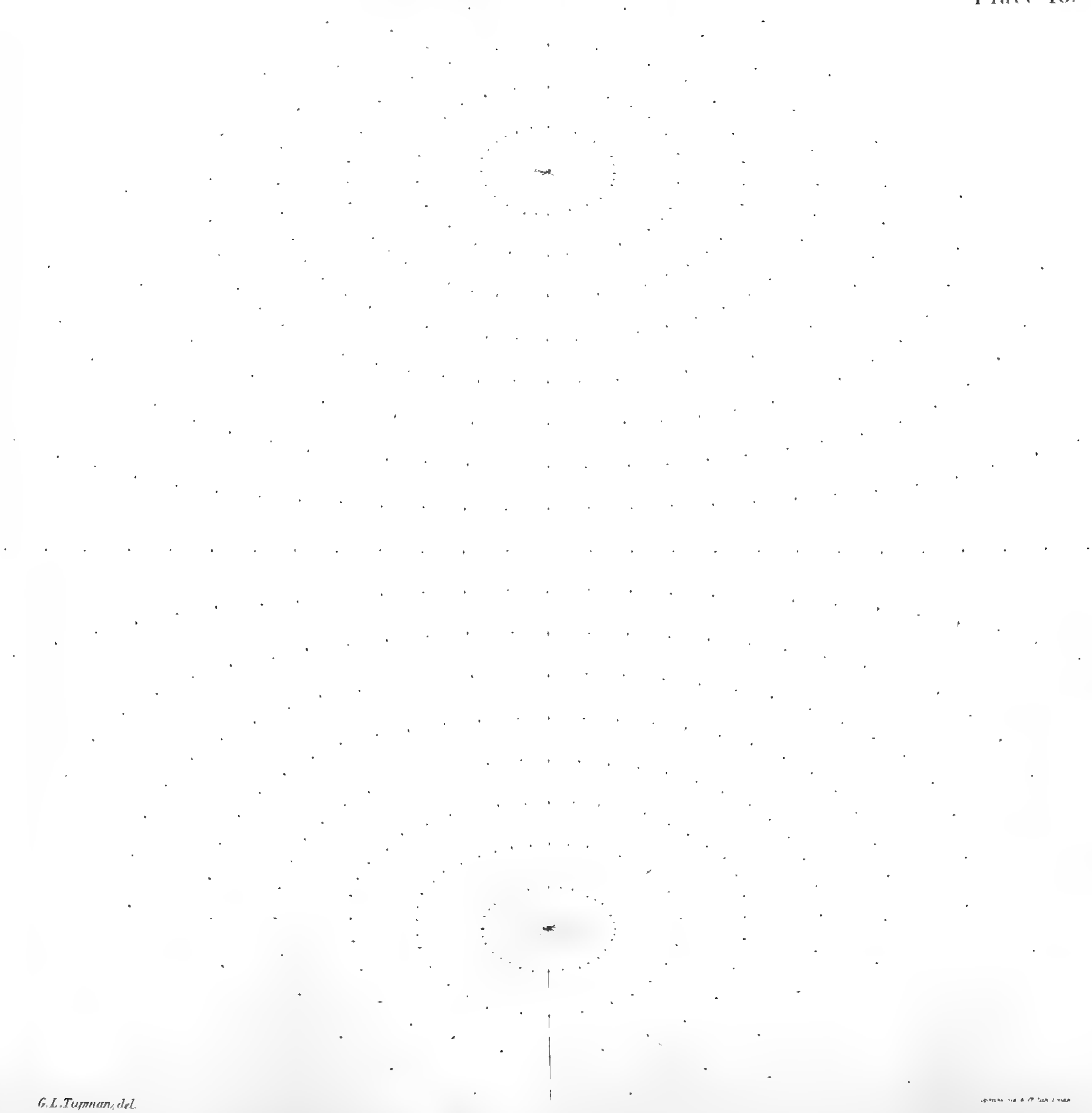
...	26 — 6					
...	9 — 15					



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List of Radiant-points of Meteor-showers, by Dr. J. F. Schmidt (Astronomische Nachrichten, No. 1756).

Epoch.	Schmidt. α δ	Heis. α δ	G. and H. α δ	Neumayer. α δ	Other Observers. α δ	
	° °	° °	° °	° °	° °	
January	93+21					
”	105+44					
”	115+15					
”	North pole.	290+84	10+85			
February (end)..	80+ 6					
March	162+24	173+23	161 0	174+16		
April	233+71	260+86				
May	155+ 9	....	160+15			
”	223−12	....	224−11 223− 8			
June	255+23	242+12	243+20 245+21			
”	266−12	....	....	269−11		
”	282− 3					
”	284+38	....	286+21 280+29			
”	293−11	....	....	305− 7		
”	313+12	292+15	286+21 312+21			
”	319+32	333+42	336+45			
”	335+10					
July 5–25	279+ 1	....	294+ 3			
” ”	301− 5					
” ”	278+13	262+12	257+13			
” 5–28	335+ 7	....	338+13			
” ”	314+10	....	....	305+ 5		
” 5–30	317+32	....	315+31 313+43			
” 5–31	264+25	262+12	246+21 257+13			
” ”	257− 3	....	256+ 5			
” 18–25	310−30					
” 18–28	335−27	....	338−28			
” 18–31	287−21					
” 20–31	333−14	....	....	337−10		
” ”	340− 8	....	....			
” ”	334+ 1					
” 25–31	324− 6					
” 20–31	283−27	....	....	284−40		
” (end)	277+40	....	288+42			
” ”	165+62	....	171+61			
July	266−12	....	....	269−11		
”	245−30	....	....	258−20		
”	0+17					
”	29+ 8					
”	7+ 4					
”	345+25	314+15	344+12			
”	20−11					
”	18+ 0					
August 3–10 ...	46+55	50+51	44+56 45+55	....	45+58	Twining.
” 3–12 ...	31+55	35+61	20+62			
” ” ...	50+48	51+55				
” 3–17 ...	50+62					
” 3–11 ...	56+47					
” 3–12 ...	54+28					
” ” ...	55+ 7					
” 1–12 ...	26− 6					
” ” ...	9−15					

List of Radiant-points (*continued*).

Epoch.	Schmidt. α δ	Heis. α δ	G. and H. α δ	Neumayer. α δ	Other Observers. α δ
	° °	° °	° °	° °	° °
August 4–11 ...	252+53	....	280+55		
„ 4–9 ...	304+60	297+68 304+62 306+59	302+44 298+58 307+50		
„ 1–12 ...	345− 7	....	....	337−10	
„ „ ... „ 1–31 ...	347−32 328−22	....	338−28	340−30 325−38	
„ 1–12 ...	357− 8				
„ 8–17 ...	148+67				
„ 1–31 ...	13+ 9				
„ „ ...	11+30	....	13+34 8+33		
„ 10–31 ...	255+24	262+12	257+13 262+12 246+21		
„ „ ...	266−12				
„ 3–31 ...	286−26				
„ 1–31 ...	306− 8				
„ 1–15 ...	338+30	....	333+41		
„ 1–31 ...	344−11	....	....	337−10	
„ 3–31 ...	333− 2				
„ 7–31 ...	347+51	....	347+47 335+52		
„ 3–31 ...	331−13				
„	3+ 1				
„	23+20				
„	53+ 1				
„	55−18				
„	266−42	....	....	284−40	
„	311+35	....	315+31		
„	325+ 1				
„	338+17	314+15	338+13 344+12 327+10		
September 1–14	1−15				
„ „ „ 3–14	331+ 1 346+ 3	343+10	....	346− 3	
„ 1–10	21+18				
„ 3–10	17+ 9				
„ 3–30	51+14				
„ „	0+ 1				
„ 3–27	66−22				
„ 1–10	337+20	343+10			
„	55− 6	....	....	50− 4 (Oct.)	
„	70+32	53+35			
„	290+58	293+57	285+44 282+42		
„	309+67	295+79 293+57 311+65	314+52 333+62 335+52		
„	344− 3	....	....	346− 3	
„	3+30	....	8+33 13+34		
„	33− 6	....	22− 9		
„	40− 8	....	22− 9		
„	82+ 6				
„	142+67	130+84			
„	246+20	....	246+21		
„	282−22				

List of Radiant-points (*continued*).

Epoch.	Schmidt. α δ	Heis. α δ	G. and H. α δ	Neumayer. α δ	Other Observers. α δ	
	° °	° °	° °	° °	° °	
September	311+35					
„	321−19					
„	325+ 1					
„	331−13					
„	354+43	....	347+47			
October 22 ...	62+ 6					
„ 10–27	79+13	....	83+12			
„ „	71+31	75+40				
„ 18–27	108+12					
„ „	93+17					
„ „	347+14					
„ 19–24	251+73					
„ 19–27	33+21	....	41+24			
„ 22–28	5+53	....	10+54 14+58			
„ (end)	340+58	334+54				
„ 18–27	87− 2	....	....	50− 4		
„ 19–27	34−14	....	....			
„	27− 1					
„	40−30					
„	50+ 2					
„	112+48					
„	115−10					
„	140+23					
„	316+44					
„	332− 2					
„	345+30					
November 1–6	348+52					
„ 1–13	307+53	....	290+55			
„ „	282+57	279+56	279+56			
„ „	121+65	115+55 (Dec.)				
„ 10–14	148+22	150+28 148+24	153+22 149+23	....	Many Italian, English, and American observations of this shower.	
„ 1–15	North pole.	North pole.				
„	66+65	37+59	59+58 45+60			
„	79+ 5					
„	82+45	....	83+50 74+45			
„	113+14					
„	180+65	....	157+71 160+71			
December 10–21	111+27	112+39	100+33	....	112+34	Wood, 1866.
„ „	41+12					
„	4− 4					
„	34+28					
„	55+ 5					
„	58+20					
„	73+ 4					
„	85+35	....	96+36 74+45			
„	102+19	....	....	....	107+19	Birmingham, 1867, Dec. 12.
„	105+ 6					
„	120+10	....	134+ 6			
„	130+30	....	....	....	136+29·5	Masters, 1866.
„	146+16	....	139+ 7			
„	182− 2					

A general Comparative Table of Radiant-positions and Duration of Meteor-showers *, by R. P. Greg, F.R.A.S., 1874.

Collated from the Catalogues of Prof. Heis, Signors Schiaparelli and Zezioli, Capt. G. L. Tupman, R.M.A., Dr. Julius Schmidt, British Association Reports, and other private sources.

Progressive No. 1874. R. P. Greg.	Epoch or Duration of Meteoric Shower.	Average Position of Radiant.		Name or No. of Radiant.	Authority or Reference.	Observations. N.B.—Radiant-area supposed to be 15° in diameter. Radiants: "Z." from Zezioli's observations; S. & Z. refer to Schiaparelli and Zezioli; G. & H. to Greg and Herschel's Brit. Assoc. Maps.
		R.A.	N.D.			
1.	December 20 to February 26 ...	10°	+86°	N G	G. & H.	Radiant close to *Polaris*; probably elongated.
	January	0	+90	....	Schmidt.	
	December 15 to February 14 ...	222	+87	N 21, 1, 2, 3	Heis.	
2.	December 23–27	130	+49	....	Tupman.	Centre about 135°, +48°; =comet of 1680 ☄ ? (Weiss), 132°, +21°·4.
	December 27 to January 31......	130	+47	189, 7, 23	S. & Z.	
	January 1 to February 9	135	+40	M 1, 2	G. & H.	
	January 1–15	145	+51	M 1	Heis.	
3.	January	99	+18	....	Schmidt.	Average of 93°, +21° and 105°, +15°; probably different from No. 177.
4.	December 27 to January 29 ...	203	+53	1, 6, 12, 13, 16, 18, 21, 188	S. & Z.	Radiant multiple; ? = comet 1490 ☄ (Peirce's, at 214°, +34°, Dec. 20; Hind's Elements, 179°, +69°, Jan. 9).
	January 6–29	200	+55	Z 10	G. & H.	
5.	January 5–11	170	+ 8	1792 ☄ (Weiss) 194° 25°, January 5.	Tupman.	Average of 7 radiants, Dec. 23 to Feb. 10.
6.	January 2–3	238	+45	K 1, 3	G. & H.	Masters, Jan. 2, 1863, at 238°, +46½°. A notable shower; maximum on the morning of Jan. 2–3. Annually observed since a maximum appearance in 1864.
	January 2–3 (1872)	227	+49	....	Herschel.	
	January 2–7	229	+51	....	Tupman.	
	December 15 to January 15 ...	231	+53	K 1, 3	Heis.	
	January 2–3 (1873)	234	+48	....	Denning.	

7.	January 10	10	+57	3	S. & Z.	Probable centre near 22°, +56°; hardly connected with No. 172.
	December 1–15	21	+54	A 19	Heis.	
	December 20 to January 30	21	+56	A 1, 2	G. & H.	
	December 15 to January 31	32	+56	A 20, 1, 2	Heis.	
8.	January 5, 11 (1870)	210	− 6	....	Tupman.	
9.	December to January	146	−40	Δ 1, 2	Neumayer.	See Nos. 15, 36; ? = comet 1840 I. (Weiss), at 128°·5, −28°·5, Jan. 20.
	January 5	145	−25	....	Tupman.	
10.	December 23	157	+64	187	S. & Z.	Probably the same shower: also noticed by Mr. Clark at York in 1572. ? = 1490 ♉. See above, No. 4.
	January 6	150	+67	G 2	G. & H.	
11.	December 22 to February 6?	181	+35	2, 5, 30, 185, 186	S. & Z.	Radiant-area rather large; probable centre at 180°, +35°; = comet II., 1792? (Weiss). Heis's position not quite correct?
	January 1 to 25	183	+36	M G 1	G. & H.	
	January 4 to 31	180	+35	....	Tupman.	
	January 16 to February 1	169	+45	M 2	Heis.	
12.	January 19 to February 5	209	+25	9, 14, 15, 27	S. & Z.	
	February 3–10 (1870)	177	+22	....	Tupman.	Average of 3 radiants (Nos. 2, 4, 5).
	" " "	210	+36	....	Tupman.	Tupman, No. 9.
	February 13 (1869)	205	+ 4	....	Tupman.	Tupman, No. 8; see also No. 18.
13.	January 27	132	+67	17	S. & Z.	
	January 21 to March 20?	140	+71	M 4, 5	G. & H.	
14.	January 28	67	+25	19	S. & Z.	
	December 20? to February 6	65	+20	A G 1	G. & H.	
	?	72	+18	....	Denza.	
15.	January 3 to March 16?	143	− 7	S 1, S G 1	G. & H.	
	January 4–11	145	+ 5	....	Tupman.	
	March 1	142	−25	....	Tupman.	
16.	January 9–19	72	+ 4	G 3	G. & H.	Reduced from Denza's observations in 1868, and confirmed by English observations.
17.	January 15–31	227	+54	K 2	Heis.	Centre probably at 225°, +54°.
	January 19 to February 6	242	+63	....	S. & Z.	
	January 29 to February 6	223	+54	K 2	G. & H.	By Mr. Greg, from Signor Denza's observations.
18.	January 18 to February 13	226	+30	8, 10, 20, 22, 24, 25?, 33	S. & Z.	Radiant probably multiple, with centre at 230°, +32°. ? = comet 1857 I. ♉ (Weiss), at 261°, +23°, Feb. 2.
	January 28–29	233	+34	Q, Z	G. & H.	
	Feb. 3–10 (1870), & 13 (1869)	237	+18	....	Tupman.	
19.	February 1–14	61	+56	A 3	Heis.	
20.	February 3–17	197	−17	....	Tupman.	Average of 5 subradiant positions.

* Continued from the Article in the Monthly Notices of the Royal Astronomical Society, vol. xxxii. p. 345 (1871–72, Supplementary No.).

Table of Radiant-positions, &c. (*continued*).

Progressive No. 1874. R. P. Greg.	Epoch or Duration of Meteoric Shower.	Average Position of Radiant. R.A.	Average Position of Radiant. N.D.	Name or No. of Radiant.	Authority or Reference.	Observations. N.B.—Radiant-area supposed to be 15° in diameter. Radiants: "Z." from Zezioli's observations; S. & Z. refer to Schiaparelli and Zezioli; G. & H. to Greg and Herschel's Brit. Assoc. Maps.
		°	°			
21. (46.)	February 6	183	+56	31	S. & Z.	Probably commencement of No. 46 (M 7).
	February 1–28	172	+59	M 3, 4	Heis.	
22.	February 10	290	−12	………	Tupman.	Observed position not very accurate.
	March	270	−22	………	Tupman.	See No. 52.
23.	February 3–17	219	−18	………	Tupman.	? = 1718 ☊ (Weiss), at 208°, −31°, Jan. 29.
24.	February 16	74	+48	39	S. & Z.	Radiant precise.
	February 9–17	73	+40	A 3, 4	G. & H.	
	February 15–28	76	+40	A 4	Heis.	
	(March 9–27)	74	+47	A Z 3	G. & Z.	Observed by Zezioli; reduced by Mr. Greg: meteors small.
25.	February 6–15	131	+52	28, 37	S. & Z.	Radiant elongated, according to Schiaparelli. Requires further investigation.
	March 1–15	120	+54	M 5 ?	Heis.	
26.	February 3	153	+21	26	S. & Z.	
	February 4–26	153	+35	M 3	G. & H.	
27.	February 13	260	± 0	………	Tupman.	1699 I. ☋ 266°, + 9°, Feb. 14 [1·12]. 1799 II. ☋ 272°, +11°, Feb. 15 [1·00]. 1858 IV. ☋ (Weiss), 272°, +12°, Feb. 13 [0·95].
28.	February 10 to April 2	175	+10	S 2, 3	G. & H.	
	February	174	+16	S 1	Neumayer.	Probably commencement of No. 42. If so, this radiant advances with the time from about 174° to 190° R.A., and from 20° to 0° Decl.
	February 15 to March 31	177	+13	S 1, 2, 3	Heis.	
	(March)	162	+24	………	Schmidt.	
29. (42.)	February 11–20	194	+15	S 2*a*	G. & H.	Probably commencement of S 4, No. 42. ? = comet 1797 ☋, at 210°, +10°, Feb. 18.

30.	February 17–19	238	+51	40, 41	S. & Z.	Meteors small?
31.	February 13	133	+26	32	S. & Z.	Ditto.
32.	February 14	105	+62	34	S. & Z.	Ditto.
33.	February 14	263	+68	36	S. & Z.	Ditto.
34.	February 15–28	245	+76	N 4?	Heis.	
35.	February 14–15	209	+52	35, 38	S. & Z.	Ditto.
36.	March 1	142	−25	....	Tupman.	See No. 15.
37.	February 28	80	+ 6	....	Schmidt.	
38.	March 1–15	50	+49	A 5	Heis.	Also confirmed by Italian observations. ? = Close approaches of comets 1746, 1231, March 8–10, at about 30°, +30°.
	March 1–15	50	+47	A 5	G. & H.	
39.	March 2–3	209	+18	....	Tupman.	See Nos. 29, 42, 62.
40.	March 2–3	240	+39	....	Tupman.	
41.	March 2–3 (1870) & 7 (1869)	246	+16	....	Tupman.	Possibly commencement of S Z 2 (No. 53). March 2–3 & 7, a double shower; 11 and 9 meteors per hour on March 7, 1869. ? = comet 1864 V. ☊, at 251°, −13°, March 1.
		235	−15	....	Tupman.	
	March 3–25	247	− 3	S Z 1	G. & H.	
	March 7 (1870)	246	0	....	Tupman.	
42.	March 5–17	190	+ 1	S 4	G. & H.	Probably a continuation of No. 28. If so, this radiant is a good instance of an elongated one.
	March 2–19	194	− 2	....	Tupman.	
	March	181	+ 6	S 2	Neumayer.	
43.	March 9–27	98	+46	A Z 1	G. & H.	By Mr. Greg, from Zezioli's observations, and probably connected together; meteors small.
	March 9–27	112	+32	A Z 2	G. & H.	
44.	March 11–19	204	−31	....	Tupman.	
	March	192	−38	H 1	Neumayer.	
45.	March 20 to April 25	143	+51	43, 61	S. & Z.	Central position 148°, +48°.
	March 22 to April 23	146	+46	M Z	G. & H.	
	March 16–31	150	+47	M 6	Heis.	
46. (21.)	March 17	186	+56	42?	S. & Z.	Probably continuation of M 3, 4 of Heis (No. 21). Centre at 180°, +50°.
	March 3 to April 30	180	+60	M 6, 7	G. & H.	
	April 1–15	180	+49	M 7	Heis.	
47.	March 11 to April 23	267	+53	D G 1	G. & H.	Multiple radiant? Possibly commencement of D G 2 (No. 64).
	April 1–23	256	+43	46, 49, 50, 51, 57, 60	S. & Z.	
48.	March 27 to April 30	224	+38	44, 48, 54, 65	S. & Z.	
	March 12 to April 30	223	+40	M G 2	G. & H.	

Table of Radiant-positions, &c. (*continued*).

Progressive No. 1874. R. P. Greg.	Epoch or Duration of Meteoric Shower.	Average Position of Radiant. R.A.	N.D.	Name or No. of Radiant.	Authority or Reference.	Observations. N.B.—Radiant-area supposed to be 15° in diameter. Radiants: "Z." from Zezioli's observations; S. & Z. refer to Schiaparelli and Zezioli; G. & H. to Greg and Herschel's Brit. Assoc. Maps.
		°	°			
49.	March 15 to April 20	305	+37	W Z	G. & H.	(Tupm. *caret*). An A.M. shower; *conf.* comets. 1857 V. ☊ (0·82) Apr. 4, 302°, +11°. 1763 ☋ (Weiss) (1·02) Mar. 18, 312°·5, +21°·5. 1790 III. ☊ (Weiss), (0·94) Apr. 24, 319°, +19°. Comet of 1763 elliptic; the orbits of the other two resemble each other.
50.	March 15? to April 23	268	+25	Q H 1	G. & H.	Prof. Herschel, Apr. 13, 1864=273°, +25½°; = comet I. 1861? (Weiss). Maximum Apr. 13; Mr. Greg, Apr. 20, 1872, 267°, +25°; meteors small, yellowish or white, with streaks.
	March 2–3	260	+19	………	Tupman.	
	March 14–15	266	+ 6	………	Tupman.	
	April 27	256	− 2	………	Tupman.	
	April 25	260	+24	63	S. & Z.	
51.	March 19? to April 22	277½	+34½	Q H_2	G. & H.	A notable shower; maximum 19th to 20th April, A.M.; according to Galle and Weiss, equal Comet I. 1861. The individual meteors white, rapid, flashing; called by Professor Herschel *Lyraïds.*
	April 20	267	+35	………	Serpieri.	
	April 19–20	274	+37	………	Denning.	
	April 19–20	275	+32	………	Lucas.	
	April (20) 15–30	277	+38	C	Heis.	
52.	March 25 to April 30	290	−10	O Z	G. & H.	More observations wanted.
53.	March 20 to May 29	227	− 5	S G_2 (S Z 2)	G. & H.	Possibly continuation of No. 41.
	May	223	−12	………	Schmidt.	
53*a*.	April 27–28	230	+12	………	Tupman.	Perhaps connected with No. 53:
	April	221	+20	………	Denning.	
54.	March 25 to April 24	198	+32	M G Z	G. & H.	
	April 11–29	187	+24	53, 64	S. & Z.	
	April 1–30	192	+18	S 4, 5	Heis.	
	April	185	+22	S 4	Neumayer.	

55.	March 30 to April 14	210	+54	45, 47, 55, 59	S. & Z.	This radiant-position appears to advance with the time, the shower probably enduring for ten weeks.
	April 25 to May 25	202	+52	M 6, 7, 8	G. & H.	
	May (1869)	202	+62	....	Serpieri.	
56.	April 10–14	165	+47	52, 56	S. & Z.	
	April 15–30	160	+49	M 8	Heis.	
57.	April 14	240	+55	58	S. & Z.	
57*a*.	April	233	+71	....	Schmidt.	Probably connected with Nos. 57 or 65.
58.	April 27	256	− 2	....	Tupman.	
59.	April 19–20	152	+22	M 3 Z	G. & H.	Possibly commencement of Y (No. 59*a*), with elongated radiant.
60.	April 25	256	+75	62	S. & Z.	Radiant well defined near Polaris.
	April 10 to May 4	70	+87	N 8 ?	G. & H.	
	April 1–30	267	+84	N 7, 8	Heis.	
61.	April 29 to May 2	326½	− 2	....	Tupman.	Average position of three bright showers, April 30 to May 3, 1870, and April 29, 1871.
62.	April 2 to May 4	194	+ 9	S 5, 6	G. & H.	Radiant elongated; possibly merely a continuation of No. 42.
	May	202	+ 9	S 6	Neumayer.	
63.	April 29 to June 12	123	+40	M G 4	G. & H.	
64.	April 23 to May 31	270	+55	D G 2	G. & H.	Possibly continuation of No. 47. A very well-defined, well-enduring meteor-shower, with radiant near head of Draco.
	May 25	280	+54	74	S. & Z.	
65.	April 27 to June 30	305	+80	N 9, 10	G. & H.	Radiant well defined.
	May 1–31	236	+81	N 9, 10	Heis.	
66.	May 2	292·5	+ 8·5	....	Tupman.	Average of two positions.
67.	April 12 to June 30	240	+25	Q 1, 2	G. & H.	
	May 22 to July 5	240	+24	70, 83, 87	S. & Z.	
	May 1 to June 30	237	+19	Q 1, 2	Heis.	
	June	225	+23	....	Schmidt.	
59*a*.	April 29 to May 15	163	+12	Y	G. & H.	Radiant elongated; possibly the continuation of No. 59.
	May	155	+ 9	....	Schmidt.	
68.	May 1–31	325	+55	B 1	Heis.	Probably commencement of B 2 (No. 69*a*), or connected with No. 77, equal B 1 of G. & H.
69.	May 18 to June 14	273	+34	68 ? 75, 79	S. & Z.	
	May 6 to June 30	280	+29	W	G. & H.	Possibly connected with W of Heis (No. 74).

Table of Radiant-positions, &c. (*continued*).

Progressive No. 1874. R. P. Greg.	Epoch or Duration of Meteoric Shower.	Average Position of Radiant. R.A.	Average Position of Radiant. N.D.	Name or No. of Radiant.	Authority or Reference.	Observations. N.B.—Radiant-area supposed to be 15° in diameter. Radiants: "Z." from Zezioli's observations; S. & Z. refer to Schiaparelli and Zezioli; G. & H. to Greg and Herschel's Brit. Assoc. Maps.
70.	May 22–24	301°	+37°	69, 73	S. & Z.	
71.	May 16 to June 2	235	+43	67, 71, 77	S. & Z.	Probably same shower.
	May 26	237	+59	76	S. & Z.	
72.	June	284	+36	....	Schmidt.	Compare No. 69.
	June 29–30	280	+29	....	Tupman.	
73.	May 2 to June 9	206	+39	66, 72, 78	S. & Z.	Small meteors. Possibly a multiple radiant.
74.	May 2 to June 20	312	+21	W G	G. & H.	
	June 1–30	292	+15	W	Heis.	
	June 28	302	+27	82?	S. & Z.	
	June	319	+32	....	Schmidt.	
75.	June	253	−37	A 3	Neumayer.	(See July, No. 91.)
69*a*.	June 1–30	333	+42	B 2	Heis.	Perhaps No. 68 continued (B 1 of Heis), doubtful.
76.	June 1–29	168	+55	M G 3	G. & H.	More observations needed.
77.	June 11 to July 11	315	+60	B 1	G. & H.	Perhaps connected with No. 68 (B 1 of Heis).
	July 1–31	317	+62	B 3, 4	Heis.	
	July 18–31	320	+62	94? 101, 102, 107, 104? 127	S. & Z.	
78.	June 28 to August 3	270	+51	81, 90, 95, 97, 121, 131	S. & Z.	Radiant probably multiple. Heis's position at 297°, +68°, doubtful, or perhaps connected with No. 81. A July and August shower.
	August 20–25	280	+58	....	Tupman.	
	July 25 (1872)	274	+57	....	Miss Herschel.	
	July 2 to August 16?	280	+55–65	B 3	G. & H.	
	July 8	288	+64	89	S. & Z.	[B 4 (No. 81).
	August 1–15	297	+68	B 5	Heis.	B 5 of Heis; perhaps connected with
79.	June, July, August	294	− 7	....	Schmidt.	(Average of 4 radiants at 294°, −7°.)
	June 28 to July 22	292	−11	....	Tupman.	(Average of 6 radiants at 292°, −11°.)
	June	293	−11	....	Schmidt.	
	June	305	− 7	Ξ 1	Neumayer.	

	July 5–25	301	− 5	....	Schmidt.	No. 79; probably all one meteor-shower, with average general centre of radiant at R. A. 300°, −1° S. Decl.
	July 21–22	313	− 6	....	Tupman.	
	June 7 to August 12?	294	+ 3	Q G	G. & H.	
	July	305	+ 5	Ξ 2	Neumayer.	
	June to July	313	+12	....	Schmidt.	
	June 28	305	+ 9	....	Tupman.	
	July 5–25	297	+ 6	....	Schmidt.	
	August 23	297	+ 2	....	Tupman.	
80.	June, July, August 31	266	−12	....	Schmidt.	Average of 3 subradiants. (See also No. 85.)
	June, July	263	−15	O 1, 2	Neumayer.	
81.	June 19? to August 4	304	+40	80? 86, 88, 92, 109, 112, 116, 117, 120, 126, 133	S. & Z.	Perhaps in part confounded or connected with No. 101 (B G).
	August 13	310	+58	....	Tupman.	One of perhaps several radiants in or near Cygnus. The meteors may be termed "*Cygnids.*"
	July 6 to August 4	310	+47	B 4	G. & H.	
	August 9–13?	315	+42	....	Clark.	
	August 15–31	306	+59	B 6?	Heis.	
	August 1–15	297	+68	B 5	Heis.	Heis, B 5; position probably not quite correct.
82.	July 1	235	± 0	....	Tupman.	
83.	July 4	3	+68	84	S. & Z.	Radiant not very precise?
	July 7 to August 4	12	+70	N 11	G. & H.	
84.	July 5	222	+60	85	S. & Z.	Also confirmed by Zezioli's observations.
	July 1–11?	210	+55	M G 5	G. & H.	
	July 11 (1868)	200	+55	....	Serpieri.	
85.	July 5–31	257	− 3	....	Schmidt.	
86.	July	359	+17	....	Schmidt.	
87.	July 1–15	262	+12	Q 3	Heis.	
	July 5–25	279	+ 7	....	Schmidt.	Average of 2 radiants.
88.	July 4 to September 12?	248	+18	Q 3	G. & H.	Radiant rather diffuse. Possibly connected with No. 90.
	September	246	+20	....	Schmidt.	
89.	July 4–11	210	+20	Q 4	G. & H.	Confirmed by Zezioli's observations.
90.	July 16	257	+36	Q H	G. & H.	Observed 1871 by Prof. A. S. Herschel, perhaps connected with No. 89.
	July 5–31	264	+25	....	Schmidt.	
91.	July	284	−40	Λ 4	Neumayer.	
	July, August, September	285	−24	....	Schmidt.	Average of 5 radiants.
92.	July 18–25	310	−30	....	Schmidt.	Probably not identical with No. 91.

Table of Radiant-positions, &c. (*continued*).

Progressive No. 1874. R. P. Greg.	Epoch or Duration of Meteoric Shower.	Average Position of Radiant. R.A.	Average Position of Radiant. N.D.	Name or No. of Radiant.	Authority or Reference.	Observations. N.B.—Radiant-area supposed to be 15° in diameter. Radiants: "Z." from Zezioli's observations; S. & Z. refer to Schiaparelli and Zezioli; G. & H. to Greg and Herschel's Brit. Assoc. Maps.
93.	July 1 to August 31	220°	+85°	N 11, 12, 13, 14	Heis.	Radiant precise, near *Polaris*.
	July 24 to August 11	330	+88	115, 135? 143	S. & Z.	Continued probably at No. 128 for Sept. and Oct.; at 10°, +83°, in 1871.
	August 22	300	+85	....	Tupman.	
	July 28 to September 10	359	+89	N 12, 13	G. & H.	Evidently a very long-enduring shower.
94.	July 2 to August 16	342	−34	H	G. & H.	Radiant near *Fomalhaut*; seen well by A. S. Herschel, July 28, 1865; also in England, August 9–11, 1871; also in Australia, &c.
	August	325	−38	Y 1	Neumayer.	
	July 18–28	335	−27	....	Schmidt.	
	August	328	−22	....	Schmidt.	
	August	347	−42	....	Schmidt.	Probably same as last.
95.	July 18 to August 4	344	+40	98, 100, 103, 104, 106, 113, 123, 134	S. & Z.	Perhaps connected with the "*Pegasids*," No. 97.
96.	August 3–15	337	+25	T G	G. & H.	Doubtless connected with No. 97.
	July	345	+25	....	Schmidt.	
97.	June 28	338	+13	....	Tupman.	Probably connected with subradiants 95 and 96, as an important meteor-shower in Pegasus ("*Pegasids*"), with maximum about August 10.
	June 29 to August 24	330–345	+14	T 1	G. & H.	
	June, July, August	336	+11	....	Schmidt.	
	August	338	+19	....	Schmidt.	
	August 9–13 (1871)	345	+15	....	A. S. Herschel.	
98.	July 11 to August 7	7	+50	93, 111, 129, 130, 139	S. & Z.	Perhaps connected with No. 103, R 1, 2 of G. & H.
	July 4–11?	7	+42	A 9	G. & H.	
	July 20–26	6	+59	....	Schmidt.	Also confirmed by Tacchini.
99.	July 28	174	+55	118	S. & Z.	A well-defined shower in 1869–71. Maximum about 10th August. Also seen at Oxford (Radcliffe Observatory) in 1870–71.
	July 29 to September 6	165	+53	V	G. & H.	
	End of July	165	+62	....	Schmidt.	
100.	July 30 to August 4	33	+34	125, 132	S. & Z.	
101.	July 8	316	+22	....	Tupman.	Perhaps connected with No. 81. A well-marked shower for July and

	August to September	311	+35	....	Schmidt.	August. Perhaps a shower with two or more radiants. The meteors may be called "*Cygnids.*" Shower probably endures for ten weeks.
	July 4 to August 22	315	+31	B G	G. & H.	
	July 5–30	317	+32	....	Schmidt.	
102.	July 9–21	242	+68	91, 96, 108?	S. & Z.	Radiant well defined.
	July 12–31	245	+64	B Z	G. & H.	
	August 4–11	252	+53	....	Schmidt.	
103.	July 21	11	+38	110	S. & Z.	Possibly connected with No. 98 (A 9). Seems to be a long-enduring and well-marked shower. Radiant probably elongated. (7°, +30° average of 2 radiants; 3°, +36° average of 4 radiants; 2°, +29° average of 3 radiants in 1869.)
	July 27 to August 25	3	+36	....	Tupman.	
	July 28 to September 3?	1–15	+36	R 1, 2	G. & H.	
	August	7	+30	....	Schmidt.	
	August 8–13	2	+29	....	Denza.	
	August	11	+30	....	Heis.	
104.	July 29	45	−21	....	Tupman.	
	August	55	−18	....	Schmidt.	
105.	July to August, September 30	5	− 4	....	Schmidt.	Possibly same as No. 106. Average of 6 radiants.
106.	July to August, September 10	22	+5	....	Schmidt.	(22°, +5°) average position of 10 subradiants.
107.	July	314	+10	....	Schmidt.	
108.	July 23 to August 20	50–25 44	+50–65 +56	A 10	G. & H.	Maximum August 9–11 (especially August 10, 1863); but some Perseids are occasionally visible as early as July 16 (A. S. H., 1871). N.B. The radiant-area of the "*Perseids*" is probably elongated, and it is not yet proved whether there are any distinct subradiants; = Comet III., 1862. ($45\frac{1}{2}°$, +56° average of 28 subradiants!) At $49\frac{1}{2}°$, $+56\frac{1}{2}°$ according to Dr. Weiss in 1869.
	July 15? to August 15	51	+55	A 10, 11	Heis.	
	August 6–12	45	+51	137, 139, 142, 144	S. & Z.	
	July 27 to August 22	$45\frac{1}{2}$	+56	....	Tupman.	
	August 10–12	50–30	+49–64	....	Serpieri.	
	August 10–11	41	+56	....	Schiaparelli.	
109.	July 20 to August 31	342	− 9	....	Schmidt.	342°, −9°, determined from four subradiants. N.B. Observed in 1872 in England. No. 109 seems to be very well determined.
	July 27–28	340	−16	....	Tupman.	
	August 1–31	337	−10	Σ 1	Neumayer.	
	September	334	− 3	....	Schmidt.	
110.	August 6	254	+37	136	S. & Z.	

Table of Radiant-positions, &c. (*continued*).

Progressive No. 1874. R. P. Greg.	Epoch or Duration of Meteoric Shower.	Average Position of Radiant. R.A.	Average Position of Radiant. N.D.	Name or No. of Radiant.	Authority or Reference.	Observations. N.B.—Radiant-area supposed to be 15° in diameter. Radiants: "Z." from Zezioli's observations; S. & Z. refer to Schiaparelli and Zezioli; G. & H. to Greg and Herschel's Brit. Assoc. Maps.
111.	August 10–11	° 3	° +17	....	Tacchini.	
	August	355	+18	T 1*a*	G. & H.	
	August 22 to October 15?	352	+17	T 2, 3 (4?)	G. & H.	
	September 1–30	352	+10	T 2, 3	Heis.	
	August 6, 18	3	+15	....	Tupman.	Probably a long-enduring shower, closely connected together, but hardly a continuation of No. 97 (!)
	August 20–25?	358	+ 6	....	Tupman.	
	September 3–14	346	+ 3	....	Schmidt.	
	September 7–15	345	+13	....	Tupman.	
	September 1–10	337	+20	....	Schmidt.	
	August	338	+17	....	Schmidt.	
	July, August, and September	8	+ 8	....	Schmidt.	Average of 5 subradiants.
112.	August 6–31?	335	+67	E 1	G. & H.	Precise duration uncertain, but a well-defined and persistent annual shower, with radiant in Lacerta. (See No. 125).
	August 28	340	+65	94, 145	S. & Z.	
	August 7? to September 30	350	+47	(average of 2 radiants)	Schmidt.	
	August 23 to September 22	339	+54	....	Tupman.	
113.	August 2 to September 25	285	+44	B 5	G. & H.	Well-marked shower; radiant also well defined, at 293°, +42°, Aug. 10, 1871.
	July 29–31	276	+36	122, 124	S. & Z.	
	End of July	277	+40	....	Schmidt.	
114.	August 3–30	68	+46	F G	G. & H.	68°, +46°; reduced by Mr. Greg from the 1870–71 Oxford Observatory Observations.
	September 7–15	65	+46	....	Tupman.	
115.	August 3–15	55	+26	R G 1	G. & H.	
	August 3–12	54	+28	....	Schmidt.	
	August 10	47	+18	140	S. & Z.	
116.	August 10 (1868)	33	+59	....	Forbes.	
	August 15 to September 30	38	+63	A 12, 13, 14	Heis.	
	August 29 to September 6	44	+53	....	Tupman.	
117.	August 3–12	55	+ 7	....	Schmidt.	Schmidt also for August 53°, +1°.

	August 20–25	53	+ 1	....	Tupman.	
118.	August 3–17	325	+ 1	....	Schmidt.	
	August 15–31	314	+15	T 1	Heis.	
	August 20–25	330	+12	....	Tupman.	
119.	August 23	298	+25	....	Tupman.	
	August	311	+35	....	Schmidt.	
119*a*.	August 20–25	110	+32	....	Tupman.	Only suspected (?).
120.	August	266	−42	....	Schmidt.	Seen at Athens.
	August	250	−35	Λ 5	Neumayer.	Seen in Australia.
121.	August 20–25	23	+36	....	Tupman.	
	August	23	+20	....	Schmidt.	
122.	August 22	82	+67	....	Tupman.	
123.	August 22	39	+28	....	Tupman.	
124.	August 20–25	260	+64	....	Tupman.	Possibly a continuation of BZ (No. 102).
125.	August 10 to September 30?	335	+52	E 2	G. & H.	Requires further investigation; possibly connected with E 1 (No. 112).
	September 5–20	319	+53	146, 151	S. & Z.	
126.	August 20–25	358	+ 6	....	Tupman.	
	September 3–14	346	+ 3	....	Schmidt.	
126*a*.	August 31	85	−15	....	Tupman.	
127.	August 8–17, September	145	+67	....	Schmidt.	Average of 2 radiants.
128.	September 1 to October 15	100	+85	N 15, 16, 17	Heis.	A long-enduring shower; probably continuation of No. 93 (!)
	September 19 to October 20	10	+88	N 14	G. & H.	
129.	September 6 to October 12	55	+33	147, 150, 155	S. & Z.	
	August 28 to September 5	43	+35	....	Tupman.	
	October 19–27	33	+21	....	Schmidt.	
	October 14 to November?	46	+27	R 3?	G. & H.	
	September 1 to October 15	48	+35	R 1, 2, 3	Heis.	
130.	September 1 to October 15	306	+62	B 7, 8, 9	Heis.	
	September	290	+58	....	Schmidt.	
	September	309	+67	....	Schmidt.	
131.	September 7–12	60	+65	148, 149	S. & Z.	
	September 7–15	59½	+56	....	Tupman.	
132.	September 23	28	+35	152	S. & Z.	
133.	September 6 to October	17	−10	U	G. & H.	Radiant near θ Ceti; well observed by A. S. Herschel on the 27th September, 1864. Possibly connected with No. 137 (Σ 3).
	September 22	75	+15	....	Tupman.	

Table of Radiant-positions, &c. (*continued*).

Progressive No. 1874. R. P. Greg.	Epoch or Duration of Meteoric Shower.	Average Position of Radiant. R.A.	Average Position of Radiant. N.D.	Name or No. of Radiant.	Authority or Reference.	Observations. N.B.—Radiant-area supposed to be 15° in diameter. Radiants: "Z." from Zezioli's observations; S. & Z. refer to Schiaparelli and Zezioli; G. & H. to Greg and Herschel's Brit. Assoc. Maps.
134.	September to October 27	80°	+ 9°	....	Schmidt.	Average of 2 subradiants.
	September 13–22	66	+ 4	....	Tupman.	Perhaps continuation of No. 117.
135.	September to October	70	+32	....	Schmidt.	
	August 29 to October 13	71	+29	....	Tupman.	Perhaps connected with No. 134.
136.	September 17 to November 24...	83–92	+50–55	F 1, 2	G. & H.	Probably a multiple or elongated radiant shower, with centre near 82°, +50°. Perhaps advances with the time from 75°, +45° to 90°, +54°. Forms an important and well-defined shower, 70°, +32° (?); see Nos. 134, 135.
	September 27	85	+50	....	A. S. Herschel.	
	September 28 to November 10...	82	+49	153, 162, 166	S. & Z.	
	October 16–31	72	+44	A 16	Heis.	
	October 15–16	86	+45	....	Tupman.	
	September	70	+32	....	Schmidt.	
	November	82	+45	....	Schmidt.	
137.	October 18–27	347	+14	....	Schmidt.	Possibly connected with U (No. 133).
	October	347	−11	Σ 3	Neumayer.	
	October	332	− 2	....	Schmidt.	
138.	September 3 to October	53	+ 6	....	Schmidt.	Average of 7 subradiants, 37°, −7° to 60°, +3°. [Probably one shower.]
	October	50	− 4	Ψ	Neumayer.	
	October 6–14............................	45	+ 7	....	Tupman.	Average of 6 radiants, 43°, −2° to 50°, +11°.
	September to October 19–31 ...	40	− 5	....	Schmidt.	Average of 4 subradiants (40°, −5°).
139.	October 1–15	57	+61	A 15	Heis.	Possibly connected with No. 159 and No. 168. Requires further investigation.
140.	October 5	240	+63	154	S. & Z.	
	October 19–24	251	+73	....	Schmidt.	
141.	October 21	130	+48	159	S. & Z.	
	October 3–20	142	+44	L G	G. & H.	
142.	October 12	105	+24	....	Tupman.	
	October 23	111	+29	161	S. & Z.	

143.	October 16–31	205	+85	N 18	Heis.	Possibly a continuation of No. 128; further observations required.
144.	October 16–31	334	+56	B 10	Heis.	
	End of October	340	+58	………	Schmidt.	
145.	October 16–31	23	+40	P 1	Heis.	Doubtful? Perhaps beginning of No. 167.
146.	October 18–29	283	+43	B G 6	G. & H.	More observations required.
147.	October 12	128	+20	………	Tupman.	
148.	October 11 & 12 (1869)	93	−21	………	Tupman.	Two radiants close together; perhaps the same as No. 152?
149.	October 11	150	+13	………	Tupman.	
	October	140	+23	………	Schmidt.	
150.	October 13	28	+10	………	Tupman.	
151.	October	316	+44	………	Schmidt.	
152.	October 5–14	86	− 9	………	Tupman.	
	October 18–27	87	− 2	………	Schmidt.	
153.	October 8–14	106	+ 4	………	Tupman.	
	October	108	+12	………	Schmidt.	Average of 3 subradiants.
154.	October 19–27	33	+21	………	Schmidt.	
	November 3	30	+23	………	Tupman.	
155.	October 18, Nov., Dec.?	108	+11	………	Schmidt.	Average of 3 subradiants.
	October 8 to November 7	105	+ 4	………	Tupman.	
156.	October 25 to November 21	64	+18	R G 2	G. & H.	A well-marked shower, with radiant at *α Tauri*. Observed at Greenwich, 13th Nov., 1870, at 55°, +25°. The meteors of this shower may be called "*Taurids.*"
	November 10	70	+20	165	S. & Z.	
	November 1–10	55½	+16	(average of 6 radiants)	Tupman.	
	November 1–15	55	+16	R 4	Heis.	
	November 4–6 (1869)	54	+16	………	Backhouse.	
157.	October 5–17	92	+13	………	Tupman.	A well-marked shower; radiant at *ν Orionis*, as determined by Prof. Herschel in 1864. Maximum 18–20 Oct. Meteors may be called *Orionids*.
	October 17 to November 13?	90	+15	O	G. & H.	
	October 13–21	84	+21	156, 157, 158, 160	S. & Z.	
	October to November	83	+11	………	Schmidt.	(83°, +11°) average of 6 subradiants 87°, −2° to 84°, +16°.
	October 18–21	74	+25	………	Tacchini.	(92°, +13°) average of 10 subradiants. "Tupman."
158.	October 31 to December 12	134	+ 6	L H	G. & H.	
	December	130 146 120	+30 +16 +10	………	Schmidt.	

Table of Radiant-positions &c. (*continued*).

Progressive No. 1874. R. P. Greg.	Epoch or Duration of Meteoric Shower.	Average Position of Radiant. R.A.	N.D.	Name or No. of Radiant.	Authority or Reference.	Observations. N.B.—Radiant-area supposed to be 15° in diameter. Radiants: "Z." from Zezioli's observations; S. & Z. refer to Schiaparelli and Zezioli; G. & H. to Greg and Herschel's Brit. Assoc. Map.
158.	November 7	124½°	+ 4½°	....	Tupman.	
159.	November 9	61	+42	164	S. & Z.	Compare Nos. 139, 168.
160.	November 12–13	359	+37	168, 170	S. & Z.	
	November 1–6	348	+52	....	Schmidt.	
161.	November 1–13	307	+53	....	Schmidt.	
162.	November	66	+65	....	Schmidt.	Possibly connected with No. 159.
163.	November 7	101	+ 7	....	Tupman.	
164.	November 6	59	− 8	....	Tupman.	
165.	November 7	160	+40	....	Tupman.	
166.	November 1–13	282	+57	....	Schmidt.	
	November 1–15	279	+56	D	Heis.	(? November 14.)
	November 23 to December 9	291	+53	D G 3	G. & H.	
167.	November 13–14	33	+40	....	Denza.	Perhaps a pseudo-radiant of A 16; P 2, 3; and R 3.
168.	October 16? to November 30	46	+44	P 2, 3	Heis.	(See No. 139.) Probably distinct from Nos. 172 and 173. Requires further investigation.
	November 13–14	40	+60	171	S. & Z.	
	November 23 to December 18	45	+55	A 16	G. & H.	
169.	November 13	193	+40	122	G. & H.	Observed at Greenwich, 1870; radiant near *Cor Caroli*; requires further investigation.
170.	November 12–17	117	+38	169, 172	S. & Z.	
171.	November 13–15	149	+23	L	G. & H.	"*Leonids*;" identical with Comet I., 1866. Maximum 14th Nov., 1866, with 33¼ years period.
	November 13–15	149½	+22¼	....	Tupman.	
	November 13–15	148	+24	L	Heis.	
	November 10–14	149	+22	....	Schmidt.	
172.	November 27 (1873)	25	+43	....	A. S. Herschel.	Average of 35 observers' positions of the great shower of "*Andromedes*" in 1872, determined by Mr. Herschel
	November 14	15	+62	A 17	Heis.	

	November 30	17	+47	176	S. & Z.	at 25°·1, +42°·9. (See Brit. Assoc. Report, 1873, p. 387–394.) Probable duration Nov. 23 to Dec. 4. Identical with Biela's Comet.
?	December 1–15	21	+54	A 19 ?	Heis.	
	November 19–30	15	+62	A 18	Heis.	
173.	September ? to November 25 ?	7–23	+54–61	A 14, 15	G. & H.	Probably distinct from No. 172; radiant near α Cassiopeiæ. Requires further investigation.
	October 22–28	5	+53	....	Schmidt.	
174.	November 10–11	77	+10	....	Tupman.	
	November to December	76	+ 4	....	Schmidt.	Average of 2 subradiants.
175.	November 10 to December 9	142	+36	167, 173, 177, 178, 181	S. & Z.	
	December 12	136	+30	....	Masters.	Observed 1867.
?	December	130	+30	....	Schmidt.	Possibly = No. 2.
176.	November 4 to December 19	160	+71	K G	G. & H.	Radiant elongated 140°, −170° R. A.?
	December 23	157	+64	187	S. & Z.	
177.	November 19 to December 15	123	+84	N 19, 20	Heis.	Possibly commencement of No. 1 (No. 21 of Heis)?
	November	0	+90	....	Schmidt.	
178.	November 23–26	103	+32	174, 175	S. & Z.	An important meteoric shower, "*Geminids*," with maximum 11th December. Radiant-centre near θ *Geminorum*; area probably elongated. Connected probably with an aërolitic epoch. (Average of 3 radiants = 106°, +22°.)
	November 26 to December 30	100 105	+33 +30	G 1	G. & H.	
	December 11–13	96	+24	....	Serpieri.	
	December 12	110	+40	....	Tupman.	
	December 10–21	106	+22	....	Schmidt.	
	December 12	112	+34	....	Wood.	
179.	November	180	+65	....	Schmidt.	
	December 12	180	+53	183	S. & Z.	
180.	December 10–21	41	+12	....	Schmidt.	
181.	December 9	154	+26	182	S. & Z.	
182.	December 9–21	108	+63	179, 180, 184 ?	S. & Z.	
183.	December	57	+12	....	Schmidt.	Possibly connected with No. 14.
184.	December	182	− 2	....	Schmidt.	
185.	December	34	+28	....	Schmidt.	
186.	December	4	− 4	....	Schmidt.	
187.	December to January	117	+13	....	Schmidt.	

IV. Periodical Meteor-Showers.

A collection of copious notes of the annual meteor-showers of August and December last, and of April and August in the present year, has been received, with more than ordinarily full details, from observers of these showers. An examination of them is unavoidably postponed, from their length, in this Report, and results of the comparison and reduction of the observations which are now in progress are reserved for a future communication. The annual August shower in 1873, although greatly concealed from view by clouds, was not much inferior in brightness when it was observed on the nights of August 10th and 11th to the considerable return of this shower in the year 1871. In the present year the August star-shower somewhat surpassed, especially in the brightness of its meteors, the intensity of its appearance on the two previous occasions.

Few meteors were recorded on the nights of the 18th to 21st of October, 1873, partly on account of cloudy skies; but the majority of those observed indicated, by their appearance and direction, traces of a slight return of this annual meteor-shower.

No success attended the watch kept by Captain Tupman at Greenwich from 11^h to 13^h, and by the observers at Stonyhurst College throughout the night of the 13th and 14th of November, for the return of the November shower of Leonids in 1873; a watch was also kept until $13^h\ 15^m$ on the same night, with similar results, by Mr. H. W. Jackson and F. H. Ward at Tooting. A completely overcast state of the sky prevented observations on the following night. An organized watch was also arranged to observe any recurrence that might be visible of the Andromedes of November 27th, that formed a conspicuous star-shower in the previous year. No meteors of this shower, however, were visible, although clear skies prevailed at the observing stations on the 27th and on most of the other nights in the last week of November. A brief notice of an unusual number of meteors seen on the evening of the 23rd, at Mr. Prince's Meteorological Observatory in Sussex, will be found in the notes of occasional star-showers at the end of this appendix; a solitary meteor (not an Andromede) was seen, in an attentive watch in clear moonless sky, between $7^h\ 30^m$ and 8^h P.M. on that evening, by Mr. M'Clure at Glasgow. If the recorded prevalence was yet observable, perhaps at some later hour on that evening, as described, it appears highly probable that it was connected with the branch stream of the main shower of Andromedes observed and recorded very generally on the night of the 24th of November, 1872. As far as the Committee have been able to ascertain, no traces of a return of the meteors representing Biela's comet have elsewhere been recorded as having been visible in November 1873.

With the exception of the August displays, the brightest annual meteor-shower of the past year was that of a well-marked exhibition of the Geminids on the nights of the 10th, 11th, and 12th of December, 1873. The state of the sky was favourable for observations on these nights at certain stations, and unfavourable at all of them on the 13th, so that the termination of the shower was not observed. Nearly 200 meteor-paths were mapped; and the appearances of the meteors were described by observers at Heidelberg (where Mr. J. E. Clark obtained a clear view of the shower) in Germany, and at Birmingham, Newcastle-on-Tyne, and Glasgow in England and Scotland, and the time of greatest frequency of the shower was approximately ascertained.

Meteors were less frequent on the 10th than on the two following nights; and they were visible in greatest numbers towards midnight on the night of the 11th, when the number mapped by Mr. Clark was nearly thirty in an hour. A greater number of meteor-tracks was recorded at Birmingham by Mr. Wood on the night of the 12th than on the 11th; and the number of bright meteors on the latter was also greater than on the former night; but a part only of the shooting-stars observed diverged from Gemini, the rest proceeding from six or seven other radiant-points more or less certainly included in Mr. Greg's general list. The percentage number of Geminids mapped is between forty and seventy in the different accounts, Mr. Clark's observations giving fifty-nine. Of the remaining shooting-stars mapped by Mr. Clark on the nights of the 10th and 11th, thirteen, or 20 per cent., proceeded with so much precision from an apparently new radiant-point at R.A. 57°, N. Decl. 6°, that the apparent courses of five of them prolonged backwards passed within one degree, and those of six others within two degrees of this point. The radiant-area in Gemini extended, according to Mr. Clark's description, from Greg's radiant G, near θ Geminorum, to Heis's radiant M_9, a little north of α Geminorum. Mr. Wood assigns to it a position extending from θ to α Geminorum, and Mr. Greg a region of some width in Telescopium.

The following numbers of meteors and hourly averages were recorded by the principal observers of the shower during the half hours ending at:—

	December 10th, P.M.				December 11th, P.M.				December 12th, P.M.				Total nos. mapped.
	$10^h 30^m$	11^h	$11^h 30^m$	12^h	$10^h 30^m$	11^h	$11^h 30^m$	12^h	$10^h 30^m$	11^h	$11^h 30^m$	12^h	
J. E. Clark......	6	8	9	...	5	5	12	17	...	...	...	..	62
Hourly average	12	16	18	...	10	10	24	34	...	...	...	...	...
T. H. Waller...	4*	5	5*	...	...	2†	5	6‡	...	6	4	...	37
Hourly average	12	10	15	...	...	12	10	12	...	12	8	...	...
W. H. Wood...	...	...	...	...	...	2§	6	8	...	5	7	12‖	40
Hourly average	...	...	...	...	...	8	12	16	...	10	14	24	...

The percentage numbers of meteors of different brightnesses seen during the whole watch by the same observers were found to be as follows:—

	As bright as Jupiter,	Sirius,	1st,	2nd,	3rd,	4th,	5th magnitude stars.
J. E. Clark............	5	5	14	27	16	30	3
T. H. Waller	2	7	18	40	33	...	...
W. H. Wood	...	15	13	35	37 (3rd mag. and under).		

Most of the bright meteors of the shower were Geminids; but some bright ones proceeded from the auxiliary radiant-points, of which several appear to have been contemporaneously active with the principal one of the display.

Owing to cloudy weather on the first two nights of January last, no observations of the January meteor-shower in the present year could be obtained. A watch for shower-meteors was, however, resumed on the annual date of the 19th to 21st of April, and the appearances of a few Lyraïds of this annual meteoric shower were placed on record. Although the light of the full moon, and at some stations cloudy weather, impeded observations, the results of Mr. Wood's watch at Birmingham, and of Mr. Backhouse's view of the shower at Sunderland, sufficiently determine the general character

* In 20 minutes. † In 10 minutes.
‡ From 12^h to $12^h 15^m$, six meteors mapped; hourly average 24.
§ In 15 minutes. ‖ From 12^h to $12^h 15^m$, four meteors mapped; hourly average 16.

of the April shower as it was visible at its return in 1874. In a watch of 40 minutes, kept at about 2^h A.M. on the morning of April 20th by Mr. Backhouse in an interval of almost cloudless sky, only four meteors, three of which were Lyraïds, were observed. During watches of nearly the same length, between 10^h and 11^h and between 11^h and 12^h, on the evening of April 20th, eight meteors and four meteors were mapped, four meteors in each watch being Lyraïds. A double watch of the same duration ($1^h 20^m$) on the night of the 21st only presented four meteor-tracks, of which two, as bright as Sirius, are erratic or very doubtful Lyraïds. Mr. Wood's description of the shower, as summed up from his observations in the following remarks, is very similar as to its duration and intensity.

"Night of the 19th overcast; 20th very fine. From 10^h to $10^h 30^m$, no meteors; $10^h 30^m$ till $11^h 30^m$, 10 meteors; $11^h 30^m$ till 12^h, no meteors; 12^h till $12^h 5^m$, 2 meteors. 21st, fine night; from 10^h till $11^h 15^m$, no meteors. A very bright but short return of this shower within well-defined limits. One half exceeded stars of the first magnitude, and were contributed by the different radiants in the proportion of one fourth from QH_2 (in Lyra), one sixth from Q_2, and similarly from $S_{5,6}$ and DG_2, and the remaining fourth from SG_2 and WG.

"The shower was of an intermittent character, with half-hour intervals of quiescence. The maximum was probably reached during the outburst from $10^h 30^m$ to $11^h 30^m$ P.M. on the 20th. The night following was marked by a total absence of meteors; the same feature presented itself at the brilliant return of 1863."

Mr. Clark's general remarks on the appearance of the shower at Heidelberg, and Mr. Greg's view of it in England, corroborate the above descriptions very closely. Mr. Clark writes:—"The weather during the week ending with the 19th was specially unfavourable, but since then perfectly clear. The hills behind hid the moon after 10 o'clock on the 20th, and [from $10^h 15^m$ until $12^h 30^m$] in all I saw twenty-five meteors, and mapped twenty-three. From $10^h 50^m$ to 12^h [Karlsruhe time, corresponding to about $10^h 20^m$–$11^h 30^m$ G.M.T.] there was a great run of Lyraïds; otherwise they were much outnumbered by those from other radiants. On the night of the 21st I only saw three meteors during a 40 minutes' watch. . . . From six apparent radiants meteors came as follows:—1 from 33 (of Greg's general list, 1872, =MZ; Heis's M_6); 2 from 43 ($M_{7,8}$); 2 from 35 (DG_1); 13 from 38 and 39 (Cerberus and Lyra); 5 from near 40 (SG_2); and 2 from 54 ($S_{5,6,8}$): total 25 meteor-tracks. Very few from Lyraïd region, save between $10^h 50^m$ and 12^h. On the 21st, 54 and 38, 39 seemed the chief radiants."

A rather larger proportion of Lyraïds appears to have been observed by Mr. Greg, who also communicates from his mapped observations a very exact position of the radiant-point and the following general description of the shower:—

"The night of the 20th was very favourable. I looked out from $11^h 15^m$ –$12^h 45^m$ and saw over twenty meteors, of which about fifteen were from Lyra, mostly very fine and remarkable ones, flashing and trained; very rapid when overhead, moderate in speed when near the radiant. About four or five others from Cerberus were different, also trained, but slower and duller in colour; only one other meteor not from these two radiants! The radiant seems very close to α Lyræ, perhaps 2° or 3° below it. On the evening of the 21st I looked out from 11^h to 12^h, and saw no Lyraïds, except one doubtful one not by any means from α Lyræ." The plotted apparent paths of eleven of the

fifteen Lyraïds, prolonged backwards, all pass through the small triangular area contained between the stars α, β, γ Lyræ.

Occasional notices of the unusual frequency of meteors on certain nights of the past year have been received, of which particular accounts were furnished in the following communications:—

September 1st, 1873 (Ackworth, Yorkshire).—"There was quite an abundance of meteors on the night of September 1st. Between 11^h and 12^h P.M. I heard from my brother (F. J. Clark) that nine meteors were seen, some very fine ones, mostly in the south."—J. E. Clark.

October 17th and November 23rd, 1873 (Crowborough, Sussex).—"October: during the evening of the 17th a number of small meteors were observed. November: one large meteor and many small ones were observed on the evening of the 23rd."—Summary of a meteorological journal for 1873 kept at Crowborough Beacon Observatory, by C. L. Prince, F.R.A.S. &c.

1874, March 18th and 19th (Sunderland).—"There were a good many shooting-stars on the nights of the 18th and the 19th (particulars enclosed). The paths traced backwards of six or seven of these agree with a very exact radiant-point at R.A. $157\frac{1}{2}°$, N. Decl. 13°; those of four or five others, as far as observed, with the radiant-point M_6."—T. W. Backhouse.

From the abstracts of logs kept on board of vessels supplied with meteorological instruments from the Meteorological Office of the Board of Trade during recent years, Captain H. Toynbee has obligingly furnished the Committee with the following entries of observations of shooting-stars near the Cape-Verd Islands in the month of February, remarking that in the 10-degree square of the Atlantic that includes those islands upwards of six such entries are found in the year 1860, and none in any other year. As far as these Reports extend, no unusual prevalence of shooting-stars or bright meteors in February was recorded in them in the year 1860; but the occurrence of meteor-showers on the 1st, 3rd, 6th, 7th, 14th, and 18th–21st of February, and of unusually bright meteors on the first two of these dates as well as on the 9th–11th and during the last six or seven days of February, is more or less well determined from existing records, to which the present important communication from Captain Toynbee affords a very valuable extension and corroboration.

Notes of Observations of Shooting-stars in February, observed in the North Atlantic. Communicated by Captain H. Toynbee.

Square 3. *February*. (Long. W. 20°–30°, lat. N. 0°–10°, S. of the Cape-Verd Islands.)

(The following are all that were remarked on in February.)

Sub-square.	Hour.	Day.	Year.	Remarks on Falling Stars.
15	8 P.M.	9th	1855	A few shooting-stars from S.S.W. to E.S.E.
1	4 A.M.	2nd	1860	Stars shooting from N.E. to S.
84	8 P.M.	18th	...	Stars shooting to N.E.
81	5 A.M.	23rd	...	Three stars from S.E. to N.E.: one burst, and left behind a tail of fire.
22	8 P.M.	3rd	1867	Stars shooting from S.E.
85	4 A.M.	26th	1870	Several stars shooting from S.E. to N.W.
86	10 P.M.	24th	1871	A very brilliant meteor passed from the zenith towards the N.N.E., and a quantity of small ones passed the zenith towards the N.E., E., and S.E. during the night. None visible to the westward.

Square 39. *February.* (Long. W. 20°–30°, lat. N. 10°–20°, enclosing the Cape-Verd Islands.)

(The following are all that were remarked on in February.)

Sub-square.	Hour.	Day.	Year.	Remarks on Falling Stars.
60	8 P.M.	6th	...	Shooting-stars from N.N.E. to S.S.W., one a beautiful meteor.
41	...	7th	...	One shooting-star from E. to W.
49	7 P.M.	10th	...	A yellow, red, and blue meteor shot from S.E. to N.W.
85	?	14th	1860	Several small meteors to the eastward falling S.W.
75	2 A.M.	19th	1860	Two stars in S.E. shooting to the westward.
...	4 A.M.	...	...	Two or three stars in the S.E. shooting to the south-westward.
13	8 P.M.	21st	...	A star in the N.W. shot to the northward down to the horizon.
...	11 P.M.	...	...	A star above head shot to the south-eastward.

Square 40. *February.* (Long. W. 30°–40°, lat. N. 10°–20°, W. of the Cape-Verd Islands.)

(The following is the only remark on falling stars in February.)

21	6.30 P.M.	28th	1871	A very bright meteor passed to the south-eastward, visible in daylight.

V. Papers on Meteoric Astronomy.

The following notices and abstracts of publications relating to luminous meteors are necessarily confined to brief records, from the limited extent of space available in the remainder of this Report. A review of Dr. Galle's paper on the orbits of fireballs, and principally of that of July 17th, 1873, was presented in the first Appendix; and papers of similar importance from other astronomers on the continent have been received. Professor Weiss, of Vienna, transmitted a copy of the meteor-observations at Vienna during the years 1867–1870, of whose copious contents a more particular description is at present reserved, in order that a full account of them may be given in a future Report. A letter accompanying this communication presented a list of tracks of 169 Andromedes observed at Pesth between $8^h\,15^m$ and $11^h\,15^m$ P.M. (Vienna time) on the night of November 27th, 1872, by Prof. Schenzl and Drs. Baumgartner and Kurlaender, and of 108 tracks recorded between $9^h\,15^m$ and $11^h\,15^m$ P.M. (Vienna time) on the same evening at Geneva by Mr. R. Schram, from a projection of the whole of which Dr. Weiss obtained exact indications of the following radiant-points as active during the period of the shower:—

		$\alpha=$	$\delta=$	Proportions of meteors of the shower.
Principal meteor radiant-points, Nov. 27th, 1872.	(1).........	25°·0	+44°·2............	producing 57 per cent.
	(2).........	52·2	+49·5............	„ 16 „
	(3).........	20·8	+24·6............	„ 15 „
	(4).........	349·3	+40·1............	„ 6 „
	Sporadic	....	....	„ 7 „

A copy of the 'Wiener Zeitung' of November 30th, 1872, containing his summary of correspondents' descriptions of the recent shower, was also received from Prof. Littrow of Vienna, and an *erratum* in the list of radiant-points of the shower in the No. for May, 1873, of the 'Monthly Notices' of

the Astronomical Society is pointed out in Herr von Konkoly's determination of the radiant-point. As extracted from Dr. Heis's collection (and not from Signor Denza's (D) as stated in the list) the N. declination of the radiant-point observed by Herr von Konkoly was 45°. Signor Denza's description, translated from that of Prof. von Littrow in the 'Wiener Zeitung,' gives 55° as the N. declination. In a letter since received from Herr von Konkoly he observes that his first accounts of the shower contained an eye-estimation of the position of the radiant-point, and that on afterwards pointing an equatorial telescope towards the exactly selected spot, an accurate position of the radiant-point was obtained. This was at a place in R.A. $1^h\ 45^m$ ($\pm 5^m$), Decl. $+45°$ ($\pm 1°$), or about in R.A. 26°·2, N. Decl. 45°, a position agreeing very closely with the probable true centre of the meteoric shower.

The following few observations of the radiant-point appear to have been omitted from the above-mentioned list:—

Observer.	Place of Observation.	Time of Observation. From	To	General Position of the Radiant-point by Fixed Stars, &c., and Reference.
		h m	h m	
C. Payne	Derby	7 15	7 30	Some degrees north of the Pleiades ('Astronomical Register,' January, 1873, p. 10).
M. J. Mello ...	Chesterfield	7 5	7 25	At some point between the zenith and the Pleiades (*ibid.*).
Jos. Baxendell .	Manchester ..	65 3	12 19	At 22°·5, +44°·5. Near χ Andromedæ. Centre of an oval area 12°×9°, from mapped paths of 266 "Andromedes" (Manch. Lit. and Phil. Society's Proceedings, 1872, Dec. 10).
A. Brothers ...	Manchester ..	5 50	8 30	At γ Andromedæ; a position most easy to note with accuracy in this shower (*ibid.*).

In another portion of his letter attention is directed by Herr von Konkoly to typographic errors in the accounts contained in the 'Monthly Notices' of the Astronomical Society (vol. xxiii. p. 575, and vol. xxiv. p. 82) of spectroscopic observations of a large meteor's streak and of the August shooting-stars made at his recently erected and equipped observatory at Ogyalla in Hungary. With regard to the August shooting-stars, those only which were observed by Herr von Konkoly himself were examined with the meteor-spectroscope on the nights of July 25th and 26th, 1873; while the large number of shooting-stars recorded by his assistant on these and the following nights of the August period were noted with Littrow's meteoroscope for fixing the positions with the naked eye. The spectra of three meteors seen with the meteor-spectroscope by Herr von Konkoly nearly resembled each other, that of the nucleus being continuous and the yellow sodium band being visible in the streaks. In the spectrum of the third meteor green predominated in the nucleus, and the green band of magnesium, in addition to that of sodium, was visible in the streak.

The next application of the meteor-spectroscope, described by Herr von Konkoly, was made on the streak of a large meteor on the night of the 13th of October, 1873. The streak was about 15 minutes broad when first observed, and traces of it were still visible in a comet-finder 25 minutes after the meteor had disappeared. The appearance of this streak in Browning's meteor-spectroscope showed very finely the bands of sodium and magnesium. Proceeding to direct the telescope armed with a star-spectro-

scope towards it, the bright lines of sodium and magnesium, and two lines in the red and two in the green, were found by Herr von Konkoly to be visible in its fading light. The last four lines, when compared with several Geissler tubes, were found to be absolutely coincident with those contained in the vacuum spectrum of coal-gas ("womit die Strassen beleuchtet werden,"—or "lighting"-gas, evidently misprinted "lightning"-gas in the description in the 'Monthly Notices'). The comparison occupied eleven minutes, at the end of which time the carbon lines could no longer be distinguished; but the bands of magnesium were still very finely visible with the meteor-spectroscope. Herr von Konkoly adds that accounts of the meteor's path were being collected by Prof. Galle, of Breslau; but that hitherto sufficiently accurate descriptions had not been obtained to enable its real path to be determined.

The following are descriptions of some memoirs and discussions that have recently been published on the appearances of the August and other meteoric star-showers of the last few years.

The August Perseïds, 1873. (Italian Observations.)

I. Prof. Serpieri, of Urbino, at the meeting of the Royal Lombard Institution of Science, held 8th January, 1874, read a paper on the Perseïds of August 1873, from which we condense the following brief analysis concerning the radiant-points of that shower. Prof. Serpieri and three assistants, in spite of nearly full moonlight, observed 267 meteors from the 8th to the 15th August, of which 139 were true Perseïds whose positions were duly mapped on a chart by Prof. Lorenzoni. The time of maximum for the shower was not determined, owing to clouds on the 10th August. Serpieri considers that there are two principal radiants for the Perseïds, or rather two principal axes of radiation crossing each other *obliquely* and having at the same time a nearly common centre. The one which he calls the "old" radiant, as determined (1847–1867) by Greg and Herschel in their meteor atlas, and especially by Prof. A. S. Herschel in 1863, has its position from

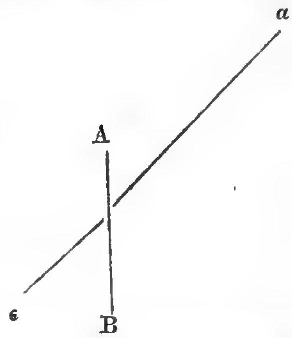
$$\left.\begin{array}{ll}\alpha \text{ Persei}\ldots\ldots\ldots\ldots & 48^\circ\ 56',+49^\circ\ 26' \\ \text{to } \epsilon \text{ Cassiopeiæ}\ldots\ldots\ldots & 26^\circ\ 27',+63^\circ\ \ 5'\end{array}\right\}\ 44^\circ,\ +56^\circ \text{ mean centre, 1863,}$$

and the "new" radiant (first determined by Prof. Newton, of America, and also confirmed by Serpieri himself) from

$$\left.\begin{array}{ll}\text{1058 Camelopardi}\ldots\ldots\ldots & 48^\circ\ 30',+59^\circ\ 30' \\ \text{to Nebula Persei}\ldots\ldots\ldots & 32^\circ\ 30',+56^\circ\ 30'\end{array}\right\}\ 44^\circ,+55^\circ \text{ mean centre.}$$

Out of the 139 Perseïds mapped for August, 1873, exactly half, or 87, are considered by Prof. Serpieri to answer the conditions as belonging to each of these two radiants. The idea entertained by Serpieri appears to be that there has in recent years (from about the year 1867) been an evident increase in the proportion of meteors affecting the "new" radiant, or radiant-axis, as compared with former years (from about 1847 to 1867, according to the English observations). The mean central points for both are apparently very nearly the same; but the meteors affect for the two radiants apparently a somewhat different range of flights, according to the mode in which Prof. Serpieri has analyzed their distribution in connexion with his definition of the radiant-regions. He considers that the meteor-flights appertaining to the "older" English radiant have a tendency to a maximum fan-like stream from *k* Persei towards that part of the heavens situate between Corona and Delphinus; whilst the tendency of the maximum streams from nearly the

same point in Perseus, for the "newer" radiant, is in a direction more oblique to the meridian, extending over the region between Corona and Pegasus as far as Algenib. Prof. Serpieri gives two drawings to show the relative position of these two radiant-axes, crossing each other near k Persei at about the angle given in the accompanying figure, with the valuable addition of the meteor-flights, indicated by arrows, as most reliably connected with either line of radiant. For A B, the "new" radiant, there are 52 meteor-tracks (1873), and for $\alpha\ \epsilon$ 50 tracks. It would appear that the apparent velocities of the A B meteors were greater than for α, and for A B also a greater number of the meteors having a less precise point of radiation. For the "new" radiant about 22 meteors showed a very good centre at R.A. 44°, Decl. +55° (Prof. Newton's centre being 43°, +57°); about 17 meteors belonging to the same current and radiant-axis, from a point at 45°, +59°; and about 8 others from one of Dr. Schmidt's radiants at 50°, +62°.



II. Prof. Serpieri, in another paper, records a strong display of the zodiacal light on the evening of the 12th December, 1873; also that Professor Denza had noticed the same evening at Montcalieri, in Piedmont, a remarkable "lucidity" over the entire sky. An unusual display of meteors (*Geminids*) were also seen at both places the same evening. As many as 80 were seen, of various sizes, by three observers (at Urbino) between $6^h\ 20^m$ and $7^h\ 15^m$. Meteors were also seen on the evenings of the 10th and 13th. The general centre of radiation was ascertained by Prof. Lorenzoni to be an area included between the points

$$\left.\begin{array}{r}\text{R.A. } 90°, \text{ Decl.} +17° \\ \text{to R.A. } 102°, \text{ Decl.} +31°\end{array}\right\} \text{Mean } 96\tfrac{1}{2}°, +24°.$$

This latter place differs somewhat from the centre of radiation for the "Geminids" of this epoch as given in the British Association Meteor-Atlas, viz. R.A. 100°, Decl. +33°; most of the meteor-paths recorded were noted in the constellation of Gemini.

III. Captain Tupman, R.M.A., in his valuable catalogue of shooting-stars and their radiant-points, lately distributed by this Committee, gives no less than 28 distinct subradiant positions connected with the Perseïds—giving an average position of 45°·5, +56°·1, as nearly as possible the definite one observed by Professors Schiaparelli, A. S. Herschel, Serpieri, and Newton; and it is also clear from Captain Tupman's observations that the duration of the Perseïd epoch is nearly a month, or from about July 27th to August 25th. That it endured from about the 27th July to the 18th or 20th August, Mr. Greg had previously entertained a strong conviction. The interesting and important question as to the radiant-area of the Perseïd shower being only a very diffuse one, or in which direction it is elongated, or whether it contains several distinct *minor* or *sub*streams of meteors and sub-radiants, has not yet been determined with certainty. During the past year Mr. J. E. Clark undertook the projection on separate maps, for intervals of successive five minutes (where the observations were sufficiently numerous), of the tracks of upwards of 2000 Perseïds described in the volumes of these Reports for former years, with a view to discover motions of the radiant-

point on successive days or hours of the night; but, as far as could be judged, without success, although a progressive motion on successive nights, like that observed by Prof. Twining in 1859, was thought to be traceable. Oscillations of the radiant-point accompanying the successive outbursts (with intervening lulls between them) very commonly occurring in the apparent intensity of the shower, were also unsupported by any signs of concentration, in these meteor-groups, of their apparent directions about definite radiant-points either movable or referable to a single place. The results in all these cases, Mr. Clark observes, although not very precise (perhaps on account of the mixed character of the observations that he employed), point to the conclusion naturally to be expected from an assemblage of such miscellaneous records, that the variations exhibited are utterly irregular from whatever point of view it was attempted to examine them.

A valuable list of upwards of 250 meteor-observations made at the Radcliffe Observatory, Oxford, during the year 1873, under the superintendence of its director, Mr. Main, has lately been published, of which copies have been presented to the Committee, and they purpose in a future Report to return to their discussion.

A fourth number of the annual directions to observers of shooting-stars in Italy was issued last year, for the period 1873–74, by Signor Denza, to astronomers and other observers engaged in contributing materials for the work of reduction continued by Professor Schiaparelli. It may be expected that the list of radiant-points obtained from these sources will contribute very largely to the correction and confirmation of the abundant collections of radiants now obtained, and to settle the doubtful questions of the distinctness or connexion together in groups or families of certain meteor-showers as exhibited in the existing lists.

Important researches have recently been made by Professor Kirkwood, of Bloomington, U.S.*, on the early recorded appearances of some of the best-known annual meteor-showers of modern dates. Those of April, October, and December are found to have been visible in past times in years which indicate a cycle for these showers of about $28\frac{1}{3}$, $27\frac{1}{2}$, and 29 years respectively in their returns. Pursuing the investigation, Professor Kirkwood recognizes similar evidence of a recurring period in the recorded dates of appearance of the star-shower of the 2nd of January, derived, however, principally from observations in the present century†. The principal appearances took place about the years 1825, 1838, and 1864, indicating as very probable a periodic time of revolution of this meteor-ring of about 13 years. [The next return of the centre of the cluster may thus be expected in 1877; and allowing two years before and after as occupied by its nodal passage, considerable returns of this meteor-shower may be anticipated during the coming years from 1875 to 1879.—*Note by the Committee*, 1874.]

Another meteor-system is indicated by Professor Kirkwood as presenting signs of recurring in old times with some regularity and frequency on a certain date, of which, unlike that last described, the modern appearances are either conjectural and uncertain or entirely wanting‡. The annual date of this shower is from the last two days in April to the first of May; its period of revolution appears to be about seven years. For the possible representa-

* See these Reports for 1871, p. 51.

† "On the Meteors of January 2nd," a paper by Prof. D. Kirkwood, read before the American Philosophical Society, November 21st, 1873.

‡ "On the Meteors of April 30th and May 1st," by Prof. D. Kirkwood, 'Nature,' May 1872.

tive of the shower in modern meteor-lists, Professor Kirkwood selects the general shower $Q_{1, 2}$ in Greg's list of 1867, diverging at the end of April and in May from the direction of Hercules (β Herculis) or Corona, some indications of that shower having a 12- or 13-year period being also noted in the meteor-list. In connexion with the very exact day of its periodical returns or of its present date on the 29th of April, Professor Kirkwood points out a resemblance between the supposed meteor-ring and the computed orbit of the comet B.C. 136, passing very near the earth's orbit and having its nodal point coincident with that date*. The radiant-point of meteor-particles from the comet at the earth's encounter with it at this node would, however, be in R.A. 320°, S. Decl. 28°*; and the star-shower that they would produce would only rise above the horizon at daybreak, having been invisible throughout the night, if the elements of the comet's orbit are correct. Another comet, that of 1006, similar, apparently, in many respects to that of B.C. 136, whose orbit is roughly assigned by Pingré as having resembled, from the comet's course, the orbit of Halley's comet, but with a different line of nodes, agrees in that respect, and in passing near the earth's orbit, with the April and May meteor-stream. As far as such imperfect descriptions of these comets as have been preserved can offer any basement for comparison, the comets of B.C. 136 and A.D. 1006 might be regarded as (except in the node and perihelion distance) resembling very nearly that of Halley's comet. Comets with such a path as Halley's comet have (for the present epoch) a date of closest approach to the earth's orbit on May 4th, with a radiant-point at about R.A. 337°, Decl. 0°. In the catalogue of meteors and meteor-showers observed by Captain Tupman, the appearance of bright star-showers on each of the nights from April 29th to May 3rd, in the years 1870–71, is recorded as the principal display of shooting-stars (omitting those of August and November) included in his three-years' watch, and the position of their radiant-point (first visible above the horizon at about 1^h A.M.) is very exactly fixed at R.A. 326°, S. Decl. 2°·5. The apparent radiant-centre of this special shower differs only ten or twelve degrees from that of Halley's comet; and the near coincidence of the time of its appearance with the date of the earth's closest proximity to the orbit of Halley's comet renders the possible identity of this meteor-stream with some dismembered fragments of the latter comet a very suggestive hypothesis, apparently deserving of more complete investigation.

As a first trial or criterion of the degree of frequency of such accordances between the apparent paths of meteor-streams and the computed elements of comet-orbits, as enumerated in a list (compiled chiefly, with later additions, from that in Hind's work on 'Comets') in the latest editions of Chambers's 'Handbook of Astronomy,' approximate calculations of the cometary radiant-points were made in those cases where the comets' paths approach (especially on the inside) to no great distance from the orbit of the earth. An attempt was also made to identify some of the radiant-points thus obtained with those of meteor-showers contained in general and in special meteor-lists. The number of approximate, though seldom very close, agreements exceeded the Committee's expectations; and however incomplete, and from since ascertained sources of error in some cases inaccurate†, the list is acknowledged in its

* [These calculations relate to the year of the comet's appearance. But for the present time, allowing for the motion of the equinox between the years B.C. 136 and A.D. 1875, the nodal date and the cometary radiant-point (uninfluenced by perturbations) would be about on May 28th, and at R.A. 350°, S. Decl. 18°.—A. S. H.]

† All great errors of this kind, it is believed, have now been removed. (*Note*, 1875.)

List of Cometary Radiant-points agreeing approximately with those of

No.	Comet and its Node.	Comet's Radius-vector at or near the Node.	Cometary-shower Date (1875).	Cometary Radiant-point (1875).		Remarks.
				R.A.	Decl.	
1.	1490 ☋ P.	0·79	Dec. 25	214°	+34°	Calculations from P. (Pierce's) and H. (Hind's) Elements. Accordance apparently very doubtful.
	,, ,, H.	0·90	Jan. 14	179	+69	
2.	1840 I ☊	0·95	,, 19	127	−28	....
	Weiss	0·96	,, 20	128·5	−28·5	....
3.	1792 ☋	1·05	,, 4	214	+16	Orbit elements apparently uncertain (?).
	Weiss	1·07	,, 5	194	+24·5	
4.	1860 IV ☊	0·96	,, 6	188	−22	....
	Weiss	0·98	,, 4	......	......	....
5.	1718 ☊	1·03	,, 29	208	−31	....
6.	1858 IV ☋	0·96	Feb. 13	272	+10	Resemble each other very closely in their orbits, and may possibly be identical.
	Weiss	0·95	,, 13	272	+12	
	1799 II ☋	0·72	,, 15	264	+17	
	1699 I ☋	1·12	,, 14	266	+ 9	
	1845 III ☋	1·06	,, 26	283	− 4	Supposed to be a return of the comet of 1596 (period 250 years). See also below, Nos. 8, 10.
7.	1857 I ☋	1·02	,, 1	261	+22	....
	Weiss	1·03	,, 2	261	+23	....
	1797 ☋	1·27	,, 18	212	+10	....
8.	1864 V. ☋	1·11	March 1	251	−13	....
9.	1862 IV ☋	0·98	March 16	250	+ 1	....
	Weiss	0·99	,, 16	249	+ 1	....
10.	1596 ☋	2·4	Feb. 23	285	− 8	....
	1845 III ☋	1·06	,, 26	283	− 4·5	[* Compare the comets 1558 and 1854 IV; considered to resemble this one remarkably in their orbits.]
	1864 V ☋	1·11	March 1	250·5	−12·5	
	*961 ☋	1·27	March 23	308	+11	
11.	1506 ☊	1·43	Feb. 6	266	−37	....
	1590 ☊	0·70	March 8	275	−38	

:nown Meteor-showers in the Northern and Southern Hemispheres.

Meteor Radiant-point.		Meteor-shower Date or Duration.	Letter or No. in Observers' Lists.	Authority.	No. in Greg's New General List.	Remarks.
R.A.	Decl.					
157°	+64°	Dec. 23..............	187	S. & Z. ...	10	
150	+67	Jan. 6..............	G_2	G. & H....	,,	
203	+53	Dec. 22–Jan. 29 ...	185, 186, 188, and 1, 2, 5, 6, &c.	S. & Z. ...	4	
200	+55	Jan. 6–29	Z_{10}	G. & H....	,,	
145	−25	,, 5..............	7	Tupman...	9	
105	−27	,, ...	Γ_2	Heis &		
145	−40	,, ...	Δ_2	Neumayer	,,	
143	− 7	,, 3–March 16	S_1 SG_1	G. & H....	15	
183	+15	,, 4–31	2, 4, 5, 8	Tupman...	5	Average radiant.
181	+35	Dec. 22–Feb. 6 ...	185, 186, 2, 5, 30.	S. & Z. ...	11	
183	+36	Jan. 1–25	MG_1	G. & H....	,,	
180	+35	,, 4–31	4	Tupman...	,,	
[169	+45	,, 16–Feb. 1 ...	M_2	Heis ?] ...	,,	
210	− 6	,, 5 and 11 }	(1870), 6, 8	Tupman...	8	
200	+ 2	,, 8–11 }				
197	−17	Feb. 3–17	6, 11, 12, 13	Tupman...	20	
260	0	,, 13 (1869) ...	16	Tupman...	27	
226	+30	Jan. 18–Feb. 13 ...	8, 10, 20, 22, 24, 25 ?, 33.	S. & Z. ...	18	
233	+34	,, 28–29	QZ	G. & H....	,,	
237	+18	{ Feb. 3–10 (1870) and Feb. 13 (1869) }	10	Tupman...	,,	
209	+25	Jan. 19–Feb. 5 ...	9, 14, 15, 27	S. & Z. ...	12	
177	+22	Feb. 3–10 (1870)	2, 4, 5	Tupman...	,,	
210	+36	,, 3–10 (1870)	9	Tupman...	,,	
205	+ 4	,, 13 (1870)...	8	Tupman...	,,	
247	+18	} March 2–3 (1870)	19, 20	Tupman...	41	
260	+19					
244	+15	} March 7 (1869) ...	19, 23	Tupman...	,,	{ Two bright showers together, twenty meteors per hour.
233	−18					
241	+ 8	March 7 (1869) }	27	Tupman...	,,	
246	0	,, 7 (1870) }				
247	− 3	,, 3–25........	SZ_1	G. & H....	,,	
260	+19	,, 2–3 (1870)	20	Tupman...	50	
266	+ 6	,, 14–15 (1869)	21	Tupman...	,,	
290	−12	Feb. 10 (1870)......	14 (not exact).	Tupman...	22	
270	−22	March 7 (1870)...	28 (only after 3 A.M.)	Tupman...	,,	
280	−38	April	Λ_1	H. & N....	......	(?)

List of Cometary Radiant-points agreeing approximately with those of known

No.	Comet and its Node.	Comet's Radius-vector at or near the Node.	Cometary-shower Date (1875).	Cometary Radiant-point (1875).		Remarks.
				R.A.	Decl.	
12.	1556 ☊	1·20	March 19	179°	−26°	The large ancient comet expected by Mr. Hind to have reappeared about the year 1860. (Period ? about 300 years.)
	1264 ☊	0·98	„ 25	182	−28	
13.	1683 ☊	1·05	„ 16	209	−50	See also below, No. 40 ....
	Weiss	1·03	„ 18	207	−48·3	....
	178 ☋	1·22	April 23	203	−32	....
14.	1854 V ☋	0·99	Feb. 13	304	+35	
	1854 IV (Weiss) ☋	0·99	„ 13	304	+37	
	1763 ☋	1·02	March 18	312	+20	Orbit a long ellipse ....
	(Weiss)............	1·02	„ 18	312	+21	
	1790 III ☋	1·06	April 24	320	+18	Resembles 1857 V (long ellipse) and 1825 I (?).
	Weiss	0·94	„ 24	319	+19	
15.	1746 (near the ☋)..	1·00	Mar. 1–8	31	+31	(Points of earth's nearest approach to the orbits.)
	1231 (near the ☋)..	1·00	„ 10	32	+31	
16.	1847 I ☋............	0·05	April 11	231	+27	Accordance with Schiaparelli's radiant-point (54) very hypothetical (Weiss and Schiaparelli) on account of the comet's very small perihelion distance.
17.	1857 V ☋	0·72	„ 4	302	+11	....
	1825 I ☋............	1·38	„ 9	312	+12	....
	1853 II ☋	0·93	May 1	296	+13	....
18.	1830 I ☊............	0·92	April 16	116	−36	Orbit supposed to be a long ellipse.
	Weiss	0·92	„ 16	......	......	
20.	1748 II ☋	0·89	„ 22	255	+27	....
	Weiss	0·89	„ 22	......	......	
21.	[1006 ☋	1·12	May 10	345	−0·5 ?]	....
[?]	[B.C. 136 ☊	1·02	„ 29	350	−18 ?]	
	1835 III (near the ☋); Halley's comet	1·00	„ 4	337	0	(Point of earth's nearest approach to the orbit.)
22.	1618 III ☋	1·10	June 10	273	0	A splendid comet; visible in the daytime.
23.	1850 I ☋............	1·08	„ 23	313	+60	Numerous radiants near this place ($B_{1,3,4}$, BG, $E_{1,2}$, G.
	Weiss	1·06	„ 24	312·5	+60·5	

& H.; B_{1-20}, Heis; and many radiant-points of Schiaparelli's and Schmidt's lists, Greg's new Catalogue, 68, 69 *a*, 77, 78, 81, 101, 112, 125, 130, 144, 151, 161, &c.) form, apparently, a continuous shower, from early in May until November, near this cometary place. The best agreement in date and position with the cometary radiant-point is that of B_1, G. & H. The above list of the next best remaining agreements in date and position shows that further corroborations of this accordance still continue to be required. (Comet visible to the naked eye, with a tail. An elliptic orbit has been assigned.)

19.	1861 I ☋............	1·00	April 20	270	+32	Visible to naked eye, with tail 3°. Elliptic orbit 415·4 years (Oppolzer). Comet of the "Lyraïds."
	Weiss	1·00	„ 20	270·4	+33·5	
24.	1864 II ☋	0·97	June 27	13	+ 6	An elliptic orbit of long period has been assigned.
	Weiss	1·05	„ 27	12	+ 6·3	

Meteor-showers in the Northern and Southern Hemispheres (*continued*).

Meteor Radiant-point. R.A.	Decl.	Meteor-shower Date or Duration.	Letter or No. in Observers' Lists.	Authority.	No. in Greg's New General List.	Remarks.
174°	−30°	March	Δ_4	H. & N.		
192	−38	March	H_1 }	H. & N. ...	44	
194	−30	April	H_2 }			
204	−31	March 11–19	17	Tupman...	,,	
305	+37	March 15–April 20	WZ	G. & H. ...	49	
50	+47	March 1–15	A_5	G. & H. ...	38	
50	+49	,, 1–15	A_5	Heis.		
223	+40	,, 12–April 30	MG_2	G. & H. ...	49	
224	+38	,, 27– ,, 30	44, 48, 64, 65.	S. & Z. ...	,,	
231	+27	April 13	54	S. & Z. ...	,,	
290	−10	March 25–April 30	OZ	G. & H. ...	52	
285	+12 }	May 2, 1870	34, 35	Tupman...	66	
298	+ 5 }					
126	−42	April	Γ_4	Heis & Neumayer		
268	+25	March 15–April 23 (max. April 13, 1864).	QH_1	G. & H. ...	50	
260	+24	April 25	63	S. & Z. ...	,,	
[256	− 2	,, 27	31	Tupman ?]	,,	
326	−2·5	April 29–May 3 ...	33	Tupman...	61	A close average position of three bright meteor-showers, 1870–71.
266	−12	June..................	....	Schmidt ...	80	
269	−11	June..................	O_1	H. & N. ...	,,	
282	− 3	,, ...	....	Schmidt.		
280	+29	May 6–June 30 ...	W	G. & H. ...	69	
292	+15	June..................	W	Heis	74	
294	+ 3	,, 7–August 12	QG	G. & H. ...	79	
315	+60	June 11–July 11	B_1	G. & H. ...	77	
325	+55	May	B_1	Heis	68	
333	+42	June..................	B_2	Heis	69 *a*	
315	+54	July 1–15...........	B_3	Heis	77	
300	+41	June 19	80	S. & Z. ...	,,	
304	+45	July 5.............	86	,, ...	,,	
288	+64	,, 8.............	89	,, ...	,,	
300	+49	,, 11.............	92	,, ...	,,	The meteor and cometary radiant-positions appear not to be identical. Compare with this No. 20.
277·5	+34·5	March 19 ?–April 22 (max. April 19–21).	QH_2	G. & H. ...	51	
277	+38	April 15–30 (max. April 20).	C	Heis	,,	
278·2	+34·5	April 20–21, 1867	....	Karlinski.		
267	+35	,, ,, 1869	....	Serpieri ...	,,	
0	+17	July	....	Schmidt...	86	

List of Cometary Radiant-points agreeing approximately with those of known

No.	Comet and its Node.	Comet's Radius-vector at or near the Node.	Cometary-shower Date (1875).	Cometary Radiant-point (1875).		Remarks.
				R.A.	Decl.	
25.	568 II ☊	0·94	Aug. 5	259°	−36°	Elements pretty trustworthy; inclination of orbit 4°. Tail 40° long.
	Ditto (near the ☊)	1·00	July 23	262	−33	
26.	B.C. 370 ☊ .... (Orbit very uncertain. No other known cometary orbit appears to represent the shower.)	1 ± (?)	Aug. ±	25±	−5±	Radiant-points about the first point of ♈, immediately above and below the equator, are very numerous in the lists of Tupman, Schmidt, Neumayer, and Greg in August and the latter end of July. The comet was observed in Greece, and it is said to have divided into two parts (Pingré).
27.	1770 I ☋	0·78	Aug. 6	283	−22	....
	Ditto (near the ☋). Lexell's comet.	1·00	July 8	276	−21	Point of nearest approach to earth's orbit.
28.	1737 II ☋	0·98	,, 30	180	+68	Elements only approximate. [MG_5 (G. & H.), Greg, No. 84, though earlier (July 1–11), and a radiant observed by Serpieri on the latter date, agree approximately in position (at 218° and 200°, +55°) with the cometary radiant-point.]
	Weiss	0·975	,, 29	175	+71	
29	1853 III ☋	0·31	Aug. 13	300	+80	Probably only an accidental resemblance on account of the small perihelion distance. (Weiss and Schiaparelli.)
	Weiss	0·31	,, 12	299	+80	
30.	1764 ☋	0·89	July 25	49	+46	....
	1862 III ☋.........	1·02	Aug. 10	43	+57·5	Comet of the "Perseïds." Bright, with tail 20°; period 123 years (Oppolzer).
	(Hind, 1872.........	....	,, 9·5	51	+52?)	
	1870 I ☋	1·01	,, 12	43·5	+53	
31.	1852 II ☊	1·00	,, 9	42	−14	....
	Weiss	1·01	,, 10	40·7	−13·5	
	1827 II ☋	0·84	,, 11	48	− 8	....
	1596 ☊	0·75	,, 27	49	− 9	....
32.	1558 ☊	0·58	,, 29	70	−22	....
	Weiss	0·89	,, 26	65	−22	
33.	1862 II ☋	1·03	,, 19	47·5	+13	Inclination of orbit small; cometary-shower date perhaps some days uncertain (Schiaparelli).
	Weiss	1·03	19	48	+14	
34.	1780 II ☋	0·82	,, 13	3·5	+38·5	This comet was only visible three days after its discovery by Montaigne and Olbers.—? if its orbit is very exactly known.

Meteor-showers in the Northern and Southern Hemispheres (*continued*).

Meteor Radiant-point. R.A.	Decl.	Meteor-shower Date or Duration.	Letter or No. in Observers' Lists.	Authority.	No. in Greg's New General List.	Remarks.
245°	−30°	July	....	Schmidt ...	91	
284	−40	"	A_5	Heis &		
258	−20	"	O_2	Neumayer.	80	
340	− 8	" 20–31	3	Schmidt ...	109	
340	−16	" 27, 28 (1870)	43	Tupman...	"	
345	− 7	Aug. 1–12	}	Schmidt ...	"	
357	− 8	" 1–12			"	
337	−10	Aug.	Σ_1	H. & N. ...	"	
344	−11	"	....	Schmidt...	"	
7	+ 4	July	}	Schmidt ...	111	
3	+ 1	Aug.				
358	+ 6	" 20–25	57	Tupman.		
285	−25	July 18–Aug. 31	....	Schmidt ...	....	Average of three radiants.
285	−13	June 28–July 6	36	Tupman...	....	Average of four radiants.
165	+62	End of July........	....	Schmidt ...	....	Compare also Nos. 22, 25 ($O_{1,2}$, H. & N.).
[240	+76	July 21	108	S. & Z.]		
174	+55	" 28	118	S. & Z. ...	99	
165	+53	" 29–Sept. 13	V	G. & H. ...	"	
0	+90	July 28–Sept. 10 ...	$N_{12, 13}$	G. & H. ...	93	
320	+82	Aug.	$N_{13, 14}$	Heis	"	
315	+80	" 5	135	S. & Z. ...	"	
0	+90	" 11	143	S. & Z. ...	"	
300	+85	" 22	52	Tupman...	"	
239	+75	" 10, 1869	....	Denza......	"	
298	+89	" 11, 1869	....	Denza......	"	
51	+55	July 15–31	A_{10}	Heis	108	The "Perseïd" comet and meteor-system appear to be a branch stream derived from the parabolic orbit of the comet 1870 I (?).
51	+55	Period of Aug. 10 ...	A_{11}	Heis	"	
50	+50	July 23–Aug. 20	A_{10}	G. & H. ...	"	
to		(max. at 44°, +56°).				
25	+65	Aug. 10, 1863.				
45·5	+56	July 27–Aug. 22 ...	....	Tupman...	"	Average of 28 subradiants.
26	− 6	Aug. 1–12	....	Schmidt.		
53	+ 1	Aug.	....	Schmidt....	117	
53	+ 1	Aug. 20–25	65	Tupman...	"	
55	−18	Aug.	....	Schmidt ...	104	
47	+18	" 10	140	S. & Z. ...	115	
54	+28	" 3–12	....	Schmidt.		
55	+ 7	" 3–12	....	Schmidt ...	117	
53	+ 1	"	....	Schmidt ...	"	
53	+ 1	" 20–25	65	Tupman...	"	
55	+26	" 3–15	RG_1	G. & H. ...	115	
344	+40	July 18–Aug. 4 ...	....	S. & Z. [?]	95	8 subradiants near η Pegasi.
11	+38	" 21	110	S. & Z. [?]	103	
3	+36	" 7–Aug. 25 ...	45,51,61,62.	Tupman...	"	
357·5	+24	Aug. 1–15 & Aug.	....	Schmidt...	"	4 radiants.
2	+29	" 8–13	....	Denza......	"	3 radiants in 1868-69.
1–15	+36	July 28–Sept. 3...	$R_{1, 2}$	G. & H. ...	"	

List of Cometary Radiant-points agreeing approximately with those of known

No.	Comet and its Node.	Comet's Radius-vector at or near the Node.	Cometary-shower Date (1875).	Cometary Radiant-point (1875). R.A.	Cometary Radiant-point (1875). Decl.	Remarks.
35.	1808 II ☊	1·07	Aug. 16	89°	+ 6°	The orbits resemble each other
	1797 ☊	0·91	„ 23	92	0	somewhat, but not very closely.
36	1854 IV ☊	1·03	Sept. 10	53	−15	The orbits of these two comets
	1854 III ☊ (Weiss)	1·02	„ 10	53	−15·8	and of the comet of 1558
	961 ☊	1·05	„ 13	49	−15·5	(No. 33) resemble each other. See also Nos. 31, 32.
37	1790 I ☋	1·07	„ 20	111	+38	Orbit-elements only approxi-
	Weiss	1·05	„ 16	109	+37·7	mate.
	1858 VI ☋	0·71	„ 8	100	+59	Donati's comet.
38	1683 ☋	1·17	„ 19	145	+50	Elliptic orbit, period 190 years; returning about the year 1870 (?). Tail 2° to 4° long.
39	1769 ☋	1·78	„ 19	18	+18	Orbit elliptic (Bessel); period
	1769 (near the ☋)	1·00	„ 28	24	+18	about 2090 (± 500) years. Tail 60°–80° long.
40	1847 VI ☋	0·74	Oct. 4	54	+52	....
41	1779 ☊	0·97	„ 18	37	−28	....
	Weiss	0·98	„ 19	39·2	−29·7	....
42	1842 II ☋	0·86	„ 21	81	+57	A small and faint comet.
	1848 I ☋	0·77	„ 24	78	+60	....
43	1739 ☋	1·08	„ 22	157	+39	....
	Weiss	1·07	„ 20	......	......	....
44	1821 ☊	1·03	Nov. 11	86	+19·5	Vis. to the naked eye; tail 2½°.
	1582 ☋	1·0	„ 9	90	+36	Elements very uncertain; mean elements of Pingré's two orbits. Comet with a faint tail.
45	1866 I ☋	0·985	„ 13	150·5	+23·5	Elliptic orbit; period 33·17 years (Oppolzer). Comet of the "Leonids."
46	1852 III ☋	0·99	„ 28	24·5	+40	Biela's comet (comet of the
	Weiss	0·99	„ 28	23·5	+43	"Andromedes").
	Hind	....	....	25·2	+42	For passage in 1866.
47	1798 II ☋	0·68	Dec. 2	162	+35	Elements only approximate.
48	1743 I ☊	0·86	Dec. 21	7	− 2	Imperfectly observed; elliptic;
	Weiss	0·88	Nov. 29	0		supposed period 5·44 years.

Meteor-showers in the Northern and Southern Hemispheres (*continued*).

Meteor Radiant-point. R.A.	Meteor Radiant-point. Decl.	Meteor-shower Date or Duration.	Letter or No. in Observers' Lists.	Authority.	No. in Greg's New General List.	Remarks.
85°	−15°	Aug. 31 (1870)......	67	Tupman...	126 *a*	
35	− 6	Sept.	....	Schmidt...	,,	
40	− 8	,, ...	....	Schmidt...	,,	
55	− 6	,, ...	....	Schmidt...	,,	
66	−22	,, 3–27.........	....	Schmidt...	,,	
110	+32	Aug. 20–25 (1871) (Suspected.)	60	Tupman...	119	
142	+67	Sept.	....	Schmidt...	127	
17	+ 9	,, 3–10	....	Schmidt...	111	(N.B. No other cometary orbit appears to represent this shower. See No. 26.)
3	+30	,, ...	....	Schmidt...	,,	
0	+ 1	,, 3–30	....	Schmidt...	,,	
359	+17	Aug. 22–Oct. 15 ...	$T_{2,3}$	G. & H. ...	,,	
1	+11	Sept. 16–30	T_3	Heis	,,	
57	+61	Oct. 1–15	A_{15}	Heis	139	
34	−14	,, 19–27	....	Schmidt...	,,	
40	−30	,, ...	....	Schmidt...	,,	
85	+50	Sept. 27 (1864)......	....	A. S. H....	136	
74	+31	Oct. 8–13	83	Tupman...	,,	3 subradiants.
86	+45	,, 15–16...........	92	Tupman...	,,	
72	+44	,, 16–31...........	A_{16}	Heis	,,	
82	+45	November	....	Schmidt...	,,	
82	+50	Sept. 17–Nov. 24 ...	$F_{1,2}$	G. & H. ...	,,	(General centre.)
142	+44	Oct. 3–20	LG	G. & H. ...	141	
130	+48	,, 21...............	159	S. & Z. ...	,,	
140	+23	,, ...	....	Schmidt...	149	
153	+13	,, 11...............	85	Tupman...	,,	
160	+40	Nov. 7	97	Tupman...	165	(Position estimated.)
90	+15	Oct. 17–Nov. 13 (?)	O	G. & H....	157	
79	+13	,, 10–27...........	....	Schmidt...	,,	
93	+17	,, 18–27...........	....	Schmidt...	,,	
79	+ 5	Nov.	....	Schmidt...	,,	
77	+10	,, 10–12...........	9	Tupman...	173	
70	+20	,, 10	165	S. & Z. ...	,,	
149	+23	,, 13–14 (1866)...	L	G. & H. ...	171	Many other Italian, English, and American observations of this shower (of the "Leonids") agree very closely with these positions.
148	+24	Period of Nov. 14	L	Heis	,,	
149·8	+22·2	Nov. 13–14 (1866)	100	Tupman...	,,	
148	+22	,, 10–14	....	Schmidt...	,,	
25	+43	,, 27 (1872)	....	G. & H. ...	172	Average of 35 good determinations.
17	+47	,, 30 (1867)	176	S. & Z. ...	,,	
21	+54	Dec. 1–15	A_{19}	Heis	,,	
145	+33	Nov. 19–Dec. 10 ...	173,178,181 182	S. & Z. ...	175	
145	+29	,, 30	177	....	,,	
136	+30	Dec. 12 (1867)......	....	Masters ...	,,	
4	− 4	Dec.	....	Schmidt...	......	Cometary radiant endures near this place throughout November, December, and January.

List of Cometary Radiant-points agreeing approximately with those of known

No.	Comet and its Node.	Comet's Radius-vector at or near the Node.	Cometary-shower Date (1875).	Cometary radiant-point (1875). R.A.	Cometary radiant-point (1875). Decl.	Remarks.
49	1812 ☋	0·80	Dec. 5	200°	+69°	Elliptic orbit period 70·7 years; naked-eye comet with tail 2° long.
	1790 II ☋	1·10	„ 20	220	+76	
	1858 I ☋	1·07	„ 20	221	+77	
50	1680 ☋	0·94	„ 27	133	+22	Comet with tail of 70° to 90°; approached almost to grazing the sun. Supposed by Halley to be periodic, but no definite period can be assigned.
	Weiss	0·96	„ 26	132	+21·4	
51	1846 VII ☋	1·09	„ 13	200	+ 4	A naked-eye comet; elliptic orbit; period 400 years (?).
	[1818 III ☋	0·87	„ 23	169	−36	Moved rapidly; a hyperbolic orbit has been assigned to it.]

present form to be, it is yet in the main a fairly correct and well verified representation of the real or apparent coincidences between meteor-showers and cometary orbits (to the close of the year 1866) that can at present be offered for purposes of preliminary use. The groups of comets as well as of meteor-showers that it presents, and the apparent replacement in some cases of formerly existing groups of comets (as those of 1264 and 1556 A.D., No. 12) by present well-established star-showers, together with the gradual changes, dismemberments, or decrease of brightness sometimes traceable in the cometary groups, are features of the list which recommend its introduction at the close of this Report, with a view to its further consideration by the Committee in future communications, with such corrections and amplifications as its present condition may require.

Copies of a paper on the "Latent Heat of Expansion, in connexion with the Luminosity of Meteors," presented to the American Philosophical Society, March 6th, 1874, were forwarded to the Committee by its author, Mr. B. V. Marsh, and have received their special attention. By means of a somewhat new mode of considering the heating-effect of compression on air, Mr. Marsh arrives at conclusions which are substantially the same as those generally admitted with regard to the high temperature and intense ignition developed by a meteorite in traversing the rarest strata of the atmosphere, and asks if such bodies traversing the outer limits of the sun's photosphere, and thence proceeding without sensible loss of their energy on their course, might not produce, without much expenditure of actual mechanical energy, the enormous luminosity of its surface. Itshould, however, be observed that the immense quantities of heat emitted from it by radiation would not on this hypothesis be accounted for.

Meteor-showers in the Northern and Southern Hemispheres (*continued*).

Meteor Radiant-point.		Meteor-shower Date or Duration.	Letter or No. in Observers' Lists.	Authority.	No. in Greg's New General List.	Remarks.
R.A.	Decl.					
123°	+78°	Dec. 1–15	N_{20}	Heis.		
120	+10	"	....	Schmidt...	158	[S. & Z. 189, T. 102, and Gruey, Dec. 10–11, 1874 (130°, +46°), perhaps represent this comet better.—*Note*, 1875.]
130	+30	"	....	Schmidt...	"	
146	+16	"	....	Schmidt...	"	
134	+ 6	Oct. 31–Dec. 12 ...	LH	G. & H. ...	"	
135	+40	Jan. 1–Feb. 9	$M_{1,2}$	[?]G. & H.	2	[?=1833 ☋ (near the node); =S. & Z. 23?—*Note*, 1875.]
182	− 2	Dec.	....	Schmidt...	184	

Report on the best means of providing for a Uniformity of Weights and Measures, with reference to the Interests of Science, by a Committee consisting of The Right Hon. Sir STAFFORD H. NORTHCOTE, *Bart., C.B., M.P.*, The Right Hon. Sir C.B. ADDERLEY, *M.P.*, Sir W. ARMSTRONG, *C.B., F.R.S.*, SAMUEL BROWN, *F.S.S.*, Dr. FARR, *F.R.S.*, A. HAMILTON, *F.G.S.*, Professor FRANKLAND, *F.R.S.*, Professor HENNESSY, *F.R.S.*, Professor LEONE LEVI, *F.S.S.* (Secretary), C. W. SIEMENS, *F.R.S.*, Professor A. W. WILLIAMSON, *F.R.S.*, Major-Gen. STRACHEY, *F.R.S.*, *and* Dr. ROBERTS.

YOUR Committee, appointed to report on the best means of providing for a uniformity of weights and measures with reference to the interest of science, have already in their several Reports indicated their opinion that such uniformity can best be promoted by the diffusion of the Metric System in all civilized countries, and by the adoption of a system of coinage founded on gold as a single standard, with a uniform proportion of alloy of one in ten and with a decimal division; and their opinion has been corroborated by the gradual extension of the Metric System, notably in the whole German empire, and by the concurrence of all nations in the same principles of coinage, though not in the identity of the unit. It is in the United Kingdom that the greatest difficulty is experienced in introducing the reform; and your Committee regret that Her Majesty's Government have as yet taken no practical step in advance of the same. Meanwhile, however, the International Metric Conference have proceeded in their deliberation and in the manufacture of perfect Metric Standards; and your Committee hope that as soon as a copy of the same shall have been deposited in this country, the Warden of the Standards will be authorized to verify by the same the Metric Weights and Measures in use in the United Kingdom, and that by this and other means the difficulties still in the way of the voluntary use of the same may be removed. Your Committee have already done their utmost to diffuse information on the subject remitted to them, but

they think it will be advisable to recommend the reappointment of the Committee; and in leaving the subject to be further matured by experience and by time, they would only reiterate their firm conviction that the uniformity of the Weights, Measures, and Coins will tend to the economy of time in the ordinary transactions of life, the extension of education and science, and the general advance of commerce and international intercourse.

NOTICES AND ABSTRACTS

OF

MISCELLANEOUS COMMUNICATIONS TO THE SECTIONS.

MATHEMATICS AND PHYSICS.

Address by The Rev. Professor J. H. Jellett, *M.A., M.R.I.A., President of the Section.*

In opening the business of the Section, my first duty is, as you will naturally anticipate, to return my warmest thanks to the British Association for the honour which they have conferred upon me by inviting me to occupy this Chair. I do it, I assure you, with all sincerity, fully sensible how high the compliment is; and if I do not dwell further upon the subject, it is, as I hope you will believe, because the President of a Section ought to occupy your time, not by speaking of himself or his own feelings, but by a review, more or less extensive, of those branches of science which form the proper business of the Section.

I say "more or less extensive;" for in determining what kind of review he will present to you, the President of this Section has a very wide range of choice. He may give you a rapid but (in its outline) complete sketch of the progress of mathematical science during the past year. He may select some one special subject, probably (and rightly) the subject with which he is himself especially conversant, giving of that a more detailed account; or he may take a middle course, neither so extensive as the first nor quite so limited as the second. It is this latter course which I wish now to take, proposing to direct your attention, during the short time which I can allow myself, to the relations, becoming every day more fully developed, not only among the branches of science which properly belong to us, but between our Section and the other Sections of the Association, or, in other words, between the sciences which we ordinarily call mathematical or physical and some of the other sciences to which the British Association is devoted. I am the more anxious to direct your attention to this class of subjects, because recent investigation has shown how fertile for discovery the "border land," if I may so call it, between sciences hitherto considered distinct has been found to be. Instances in proof of this will present themselves as we go on; some have no doubt suggested themselves to you already.

We are called, in ordinary language, the Mathematical Section. The adjective must indeed be understood in a very wide sense—too wide perhaps for strict propriety of language, if it be meant to include every thing to which our labours here are devoted; still the use of the term "mathematical" indicates, and truly indicates, the preponderance which in this Section we give to mathematics and to those sciences which are at present capable of mathematical treatment; and therefore the first question which in the consideration of our present subject naturally presents itself is, Does this list of sciences show any prospect of increase? Are we making, are we likely to make, an increased use of mathematics as an instrument of physical investigation? Are we trying to improve its use in those

sciences which are already recognized as belonging to its legitimate province? Are we trying to perfect the mathematical treatment of such sciences as optics or electricity, which have been already brought under the sway of mathematics? Are we trying to extend its sway by bringing under it sciences (chemistry, for example, or biology) in which as yet its power has been but little felt? Or have we come to the conclusion, to which some writers would lead us, that we have already pushed the use of mathematics too far? Is it true, for example, and do we feel it to be true, that in our anxiety to bring physical optics completely under the power of mathematical science, we have abandoned the principles of the inductive philosophy, and substituted mere hypotheses for true knowledge? And are we convinced, at least, that every chemist is bound, as he values the truth and reality of his science, to resist the introduction into chemistry of the methods of mathematical analysis, if any such attempt should be made?

This latter is the opinion of Comte, whose severe strictures on the application of mathematical analysis to physical optics I shall have to consider further on; for the present I would confine your attention to the inquiry, What indications on this subject are presented by the actual progress of physical science? Does its history exhibit a tendency to widen or to contract the field of mathematical analysis?

In reviewing, with this purpose, the history of physical science, we may leave out of sight those sciences, or parts of a science, to which the methods and language of mathematics are applicable without the aid of hypotheses. No scientific man doubts the advantage of applying, as far as our analytic powers enable us so to do, the methods of mathematical analysis to such sciences as plain optics or plain astronomy. Even physical astronomy, although in strict logical precision not wholly independent of hypothesis, has been long recognized as, in the most proper sense of the word, a mathematical science. Wherever, in fact, the fundamental equations rest either on direct observation (as in plain optics) or (as in physical astronomy) upon an hypothesis, if we may venture to call it an hypothesis, so entirely accepted as universal gravitation, the extension of the methods of mathematics is only limited by the weakness of mathematical analysis itself. But there are other sciences, as, for example, physical optics, to which mathematical analysis cannot be applied without the intervention of hypotheses more or less uncertain. And if we would appreciate the true character of scientific progress, the question which we must put to scientific history is this, Is science becoming more or less tolerant of such hypotheses? A principle is assumed, possessing in itself a certain amount of plausibility, and capable of mathematical expression, from which we are able to deduce, as consequences and by mathematical reasoning, phenomena whose reality may afterwards be proved by direct experiment. And from this experimental verification we infer, with more or less probability, the truth of the original assumption. The question, then, which we have to put to scientific history is this, Do the records of science indicate a greater or a less tolerance of this kind of logic? Is the mode of physical investigation which I have shortly sketched gaining or losing the favour of scientific men?

Passing over sciences like astronomy, which, though not wholly free from hypothesis, do not give us very extended information on this point, I come to a part of scientific history to which we may put the question with every probability of obtaining (so far, at least, as one science is concerned) a decisive answer—I mean, the history of physical optics.

We have here a science whose basis is purely hypothetical. The definition of light is an hypothesis, the nature of the æthereal motion is an hypothesis, even the very existence of the æther is an hypothesis—hypotheses, indeed, which have led to conclusions amply verified by experiment, but hypotheses still. Does the history of optical science indicate a desire to discard this hypothetical base? Does the history of this science betray a tendency on the part of scientific men to abandon or neglect mechanical theories of light? Have physicists given up as hopeless, or perhaps unphilosophical, the attempt to reduce, by the intervention of a supposed æther, the phenomena of light under the mathematical laws which govern motion? Are they even abandoning the reasoning or the phraseology of the undulatory system? The answer to these questions is not doubtful. Com-

mencing with Fresnel, more than half a century ago, the history of physical optics is a history of efforts, constantly repeated, to frame what M. de St. Venant has called "a really rational theory of light."

Take, for example, the repeated attempts to reconcile the mechanical principle of continuity with the optical phenomenon of double refraction. When the movement which we call light passes from one medium to another, if the molecular movement be continuous, it is hard to see how the elastic force of the æther can be different at different sides of the plane of separation. It would seem, then, that the principle requires that the elastic force of the æther should be the same in all media. But if it be the same in a crystalline as in an uncrystalline medium, it ought to be the same in every direction; and if it be the same in every direction, how are we to account for the phenomenon of double refraction? The effort to overcome this difficulty may be said to have engaged the attention of Cauchy during all the latter part of his life. The same question was taken up after his death by other writers, among whom I may mention M. Boussinesq as the most recent, and is to this day a question of great interest to mathematical physicists. I am not now inquiring whether the reasoning which I have just stated be valid, or whether the difficulty, which some writers do not appear to have felt, be real. I allude to it only as a proof of the anxiety felt by men who have borne the greatest names in optical science to have a complete mechanical theory of light. It would be easy to multiply instances, affecting all the great phenomena of optics, which evince the same anxiety.

Another and even stronger proof of the firm footing which the undulatory theory has obtained in the world of science is the familiarity with which we use the terms of that theory, as if they denoted actual physical realities. When, not long since, much labour was expended in calculating the wave-lengths for the several rays of the spectrum, there does not appear to have been among physicists any consciousness that they were discussing, and even professing to measure, things which had no existence but in the fancy of mathematicians. On the contrary, we have come to speak of wave-lengths quite as freely and as familiarly as we speak of indices of refraction. Nor is this true only of detached memoirs, which might be supposed to represent only individual opinion. The language and the principles of the undulatory theory have found their way into our ordinary text-books—a sure proof that these principles have been generally accepted by the scientific world. I am not now discussing the question whether, regarded as an indication of scientific progress, this fact is favourable or unfavourable. I only say that it *is* a fact. M. Comte has done all that the hard words of a man of great genius could do to banish theories of light from the domain of science, but his greatest admirer will hardly say that he has been successful.

I pass to the consideration of another branch of science, closely connected with, and indeed including, physical optics, and exemplifying, even more strongly, the desire of scientific men to extend the sway of mathematics over physical science—I mean, Molecular Mechanics. This branch of mechanical science (if, indeed, it be not more correct to say, this science) is altogether modern. Fifty years ago it had hardly begun to exist, and even now it is in a very imperfect condition. Imperfect as it is, however, it has advanced far enough to mark the progress of science in the direction which I have indicated. And as it is a science more general than physical optics, the indications which we can gather from it are more important. Physical optics does not take us outside our own Section; molecular mechanics shows a marked tendency to carry mathematical analysis into the domain of chemistry. If it shall ever be possible to establish an intimate connexion between this latter science and theoretical mechanics, it is probably here that we shall find the connecting link. In truth it is impossible to contemplate the ever-growing tendency of science to see in so many natural phenomena varieties of motion, without anticipating a time when mathematical dynamics (the science which has already reduced so many of the phenomena of motion beneath the power of mathematical analysis) shall be admitted to be the universal interpreter of nature, as completely as it is now admitted to be the interpreter of the motions of the planets. I do not say that it will ever be. I do not even say that it is possible. It is no true philosophy which dogmatizes on the future of science. But it is certain that the current

of scientific thought is setting strongly in that direction. The constant tendency of scientific thought is, as I have said, to increase the number of those phenomena which are regarded as mere varieties of motion. Sound—that we have placed on the list long since. Light, though here our conclusions are more hypothetical, we have also long regarded as belonging to the same category; and Heat may now be fairly added; and we have almost learned, under the guidance of Professor Williamson, to regard chemical combination as a phenomenon of the same kind. All these phenomena (of sound, of light, of heat, and perhaps even of chemical combination) we now regard as produced by the movements of systems of exceedingly small particles—whether of known particles, as in the case of sound, or of the hypothetical æther, as in the case of light; and a science which proposes to itself the mathematical discussion of the laws which govern the movements of such systems can hardly fail to play an important part in the future history of physical science. I shall not then, I hope, be thought to misemploy the time of the Section by offering some observations on the science of molecular dynamics.

When we have to deal with a science which professes to be more than a mathematical abstraction—a science which assumes to itself the function of representing, with at least approximate truth, the realities of nature—our first question will naturally be, What is the basis on which it rests? Is it built upon a pure hypothesis, not derived from experiment, but seeking to justify its claim to reality by the truth of the results which may be deduced from it?

The word "molecule," as Prof. Clerk Maxwell has told us, is modern, embodying an idea derived from modern chemistry. It denotes a material particle so small as to be incapable of subdivision into parts similar in their nature to itself. Thus a drop of water may be divided into smaller drops, each of which is also water; but a *molecule* of water is regarded as incapable of such division. Not that we regard it as absolutely indivisible; but we assume that a further division, could it be effected, would produce molecules, not of water, but of its component gases, hydrogen and oxygen.

Now this conception of a molecule undoubtedly involves an hypothesis. Are there such ultimate particles of matter, not only resisting all the dividing forces which we can command, but absolutely indivisible, by *any* force, into particles similar to each other, or perhaps into particles of any kind? Or are we to suppose that, if we had instruments of sufficient delicacy, the process of division might be carried on without limit? Experiment gives us no means of deciding between these alternatives; and if the exigencies of our method of investigation force us to make a decision, we can make it only by an hypothesis. But we may fairly ask, Does the logic of molecular dynamics absolutely require this decision? And on this point I wish to offer one or two remarks. When we propose to determine the motion of a body, solid or fluid, we ought, as indeed in all scientific problems, to form in the first place a clear conception of the meaning of the question which we propose to ourselves. We wish to discover the laws which govern the motion—of what? Not certainly of the body taken as a whole. That is, no doubt, part of the information which we seek, but a very small part of it. When we have learned to determine by a fixed mathematical rule, or formula as we generally call it, the position occupied at any instant by the centre of gravity of the body and by its principal axes, we have learned something, but the investigation is far from being complete. There are, as you know, large classes of movements of which such knowledge would tell us nothing. Thus, to take a familiar instance, you see a man (to use our ordinary language) "sitting quiet." He is at rest, so far as the movement of the body, taken as a whole, is concerned. He is neither turning on his chair nor walking about the room; and yet there is probably not a single particle of his body which is absolutely quiescent. You see, then, how ignorant we are of the vital movements of the human body, if we know only that the individual is "sitting quiet."

But suppose that we push the inquiry a little further and propose to investigate the motion of the blood. We obtain an answer to this question in one sense by determining the rate at which the blood, taken as a whole, is moving—that is to say, suppose the number of ounces of blood which pass through the mitral valve in the space of one minute; but having learned this, we are still very far from

knowing completely the motion of the blood. But suppose that we were able to assign at any instant the position of each one of the blood-globules considered as a unit—that is to say, suppose we could assign for each of these globules the position of its centre of gravity and the positions of its principal axes, we should then know the motion of the blood, not, indeed, perfectly (for we should still be ignorant of the motion of the *serum* as well as of the internal movements which take place in each globule), but very much more completely than before.

Further (and this is the point to which I wish especially to direct your attention), these results would be equally true, whether the globules were really units, incapable of further subdivision, or really aggregates of still smaller particles. In the former case we should know perfectly the motion of that part of the blood which consists of the red globules; in the latter, we should know the same motion, but not perfectly; that is to say, our results, though true as far as they go, would leave us still in ignorance of one or more classes of motions which are really exhibited by the globules of the blood. We should then be obliged to imagine a still further subdivision. If, for example, we divided, in imagination, each globule into a thousand parts, and could determine the motion of each part considered as a unit, our results would still further approximate to completeness; and so on for further subdivisions. The logic of molecular dynamics may then be shortly stated as follows:—

In seeking to form the equations of motion of a body, solid or fluid, we commence by an imaginary division of the body into elements of any arbitrary magnitude, and we form the equations of motion for each of these elements considered as a unit. The results so obtained are true, but, as long as the elements retain a finite magnitude, incomplete. They do not give us full information as to the movement of the system. But suppose now, adopting the spirit of the differential calculus, that the magnitude of these elements is constantly diminished; then it will be found that, as in the differential calculus, these equations tend towards a certain limiting form, constantly approaching it as the magnitude of the elements is continually diminished; and in this limiting form these equations are not only true but complete.

Stated in this general form, the principles of molecular dynamics are not only perfectly logical, but wholly free from hypothesis. Hypotheses have, no doubt, been freely introduced for the purpose of forming the actual equations in any given case; but molecular dynamics, as such, is not an hypothetical science. The word molecular is in some respects unfortunate, as tending to identify the science with a particular hypothesis as to the constitution of matter. But molecular dynamics as a science has no necessary connexion with the molecular hypothesis. In truth the methods of this science harmonize quite as readily with the supposition of the infinite divisibility of matter as with the supposition of ultimate molecules.

Molecular dynamics may fairly be called the differential calculus of physical science. It is, in its relation to physical science, what the differential calculus is in its relation to geometry. As in geometry, when we would pass from the small and exceptional class of rectilinear figures to the infinite varieties of curve-lines, we must invoke the aid of the differential calculus, so when we would pass from the abstractions of rigid solids and unbending surfaces to the contemplation of bodies as they really exist in nature, must we, if we would fully investigate their phenomena, invoke the aid of molecular dynamics. It is the science of that phenomenon which is gradually drawing all others within its sway; it is the science of that phenomenon which, "changed in all and yet in all the same," we have learned to see in every part of nature. Molecular dynamics is the science of Motion in its widest and truest sense—of the motion which passes along in the sweep of the tempest or the fierce throb of the earthquake—of the motion (no less real) which breathes in the gentlest whisper or thrills along the minutest nerve.

I have dwelt thus long upon the subject of molecular dynamics because the amount of attention which in the present century it has commanded, and the great advance which it has made, mark most distinctly the tendency of scientific thought to the introduction of mathematical analysis into all parts of physical science; for molecular dynamics is the key to this introduction. It is to the perfection of this

science that we must look for an increased use of the mathematical instrument; and when we combine the indications afforded by the history of this science with those which we may derive from the history of its principal application (Physical Optics) we have at least this partial answer to our question—Mathematical analysis shows no sign of relaxing its grasp upon any of the sciences which have been hitherto considered to belong to its domain; nay, more, the desire to extend that domain is indicated by the efforts to perfect the instrument by which that extension must be made. We may now ask, Is this indication confirmed by the history of any of those sciences which have been hitherto regarded as lying wholly without our Section?

And first, what shall we say of Section B? Does chemical science show any indications pointing to a future union with the group already collected under the *genus* (if I may so call it) Theoretical Mechanics? Take, for example, the great problem of chemical combination. Does the treatment of this problem now show any signs pointing in the direction of dynamical science? I desire here to speak with all reserve and even hesitation, being conscious that I am no longer on familiar ground. Still there are signs which even an outside spectator may read. And we may, I think, speak confidently of their direction, although the goal to which they point is far distant and may perhaps be unattainable.

One of these signs is the appearance of *time* as one of the elements of a chemical problem. And in recognizing the necessity of a certain time for the production of a chemical effect, chemists are now pointing not obscurely to the analogy of mechanical science. "Time," says Berthelot, "is necessary for the accomplishment of chemical reactions, as it is for all the other mechanical phenomena." This might not in itself be very significant; but chemists have not merely recognized the necessity of time as a condition for the production of chemical phenomena, they have also undertaken to measure it; or rather, taking the converse problem, they have undertaken to measure the amount of chemical effect produced in the unit of time; and the law of this phenomenon announced by Berthelot takes (necessarily, indeed) a mathematical form quite analogous to equations which present themselves in dynamical science. The next step has followed as a matter of course, and chemists now speak as familiarly of the *velocity* of chemical reactions as engineers do of the velocity of a cannon-ball.

Still more important in its bearing on the future of chemistry, and tending distinctly in the same direction, is the theory of Chemical Combination, which science owes to Prof. Williamson, and according to which this phenomenon, like so many others, ought to be regarded as in great measure a mode of motion. We suppose the normal condition of the atomic constituents of a body to be *motion*, not rest; and when we say that a molecule of one substance enters into *combination* with a molecule of another substance, we do not mean that the same molecules constantly adhere together, but that the union between the molecules, whatever be its nature, is continually dissolved and as continually re-formed. According to this theory, chemical equilibrium does not denote molecular rest, but a system of molecular motion, in which these decompositions and recompositions balance each other.

If I may venture to add any thing to that which comes from such an authority, I would say that this theory leads us naturally to regard the chemical properties of bodies as, if not wholly modes of motion, yet largely dependent upon the nature of the movements which take place among their constituent atoms. Hence, if two bodies incapable of chemical action are brought into chemical presence of each other, we may suppose that their atomic movements, and therefore their properties, remain unaltered. If, on the other hand, these bodies be capable of acting chemically on each other, their atomic movements are modified by their mutual chemical presence; and therefore the chemical properties of the compound, as we call it, may be wholly different from those of either of the bodies which have entered into combination.

Now we are not yet prepared to consider chemical combination as a problem of molecular dynamics. We have not sufficiently clear ideas (even hypothetical ideas) of these atomic movements, and of the modifications which are caused by the chemical presence of another body, to place the investigation of these phe-

nomena in the same category with the investigation of the phenomena of physical optics; and I am sure that any attempt to hasten unduly the affiliation of chemistry to theoretical dynamics would be productive of serious mischief. The drift of the remarks which I have made has been only to show that the current of scientific thought is setting in that direction; and while we may not predict such an affiliation, still less should we be justified in pronouncing it to be beyond the possibilities or even the probabilities of science.

Time will only allow me to notice very briefly another important application of mathematics to a branch of science considered hitherto to be altogether beyond the limits of our Section,—I refer to the application of the methods of geometry and theoretical mechanics to Biological science recently made by Professor Haughton.

The first example which I shall notice is the establishment of a principle governing the animal frame, and quite analogous to the principle of "least action" in dynamics. This principle asserts that every muscle is so framed as to perform the greatest amount of work under the given external circumstances. If this principle be admitted as an *à priori* truth, the arrangement of any given muscle may be mathematically deduced from it; but many, no doubt, will prefer to regard it as an inductive truth established by the number of instances which Professor Haughton has adduced and discussed. Among these the work done by the human heart is considered; and in order more fully to exemplify the principle of the economy of work, Professor Haughton has imagined a very obvious construction of the heart in which the principle would be violated, contrasting this with the actual construction in which, as he has shown, the principle is preserved.

Professor Haughton has also made much use of the geometry of curved surfaces in estimating the action of the non-plane muscles.

On the whole the work of Professor Haughton is a remarkable example of the increasing use of mathematical methods in the investigation of physical problems.

We have put to scientific history the important question—Is it probable that the dominion of mathematics over physical science will be more widely extended than it is at present? Is it probable, not only that we shall improve the mathematical instrument as applied to those sciences which are already recognized as belonging to the legitimate province of mathematical analysis, but also that we shall learn to apply the same instrument to sciences which are now wholly or partially independent of its authority? And to this question I think that scientific history must answer, Yes, it *is* probable. It is probable, because physical science is learning more and more every day to see in the phenomena of nature modifications of that one phenomenon which is peculiarly under the power of mathematics. It is probable, because science already indicates the path by which that advance will be made, because we already possess in molecular dynamics a method (the creation, I may almost say, of our own age, and still very imperfect) whose proper subject is motion not in any limited or abstract sense, but as widely as it really exists in nature. And it is probable, because we cannot look back on the history of science for the last fifty years without becoming conscious how large is the advance which has been already made.

I have thus far endeavoured to show to you the light which is thrown on the connexion between physical science and mathematical analysis by actual scientific history; and I have given you some reasons for believing, so far as it is permitted to us to read the future, that this connexion is likely to extend still more widely.

But before we pass from this part of the subject, we are bound to ask the question, Are we to regard this indication as being favourable to the cause of scientific progress? Shall we regard the tendency to use, as far as possible, the mathematical instrument in physical investigation as being likely to extend our real knowledge of nature? Or will its result be merely to encourage the formation of vain hypotheses, recommended only by their capability of mathematical expression, and deeply injuring the cause of science by means of the facility with which men accept such speculations as real knowledge? This latter opinion seems to be, on the whole, that of Comte, whose severe strictures upon physical theories of light I have noticed before.

Now I believe that the advocate of the mathematical method of investigation

might be, and would be, perfectly content to fight the battle of mathematical physics on the ground which Comte himself has chosen. We have put one important question to the history of science, let us put another.

Has the effect of theories of light upon the progress of real optical knowledge (knowledge which Comte himself would admit to be real) been beneficial or injurious?

This question belongs to a class to which the answer is never easy. It is never an easy task to abstract one from a group of causes which concur in the production of an effect, and then determine how the effect would have been changed by such removal. Still we may succeed in obtaining at least a partial answer to the question.

It has been frequently remarked as one of the benefits conferred upon physical science by theory, that it suggests experiment. Nowhere is this principle more strongly exemplified than in the history of perhaps the greatest name in optical science—I mean, Fresnel. He is an experimentalist certainly; but he is an experimentalist because he is a theorist. His most valuable experiments had their origin in the desire to test the truth of a theory. The experiment with the two mirrors were devised to test Young's principle of interference. His diffraction experiments were devised at first to test the truth of Young's theory; and when that had been found to be inconsistent with fact, then to test the truth of his own. And, not to multiply instances, the experiments by which he established the existence of circular polarization, and ascertained the true nature of the light which passes along the axis of a quartz crystal, were suggested by theory.

Among the motives which induced Jamin to undertake the experimental researches which have given to science such valuable results, not the least was the desire to test the truth of an hypothetical principle of Fresnel and of a theoretic formula of Cauchy. And quite recently M. Abria has made an elaborate examination of uniaxal refraction for the purpose of testing the truth of the construction of Huyghens. I may here remark that it is much to be desired that some competent observer would undertake the yet more difficult task of verifying experimentally the wave-surface of Fresnel.

But to revert to the general subject. If any physicist is inclined to agree with the views of Comte upon this subject, let me propose to him the following test:—Let him strike out of physical optics every thing which that science owes to theories of light, and then let him try to write a treatise on the subject, excluding the language and the ideas of theory. Finally, let him compare his work with some treatise in which these aids have not been neglected, and judge himself of their relative value. Theoretic science need not be afraid of the result.

Naturally suggested by the subject which we have been considering, namely, the tendency of scientific progress to a reduction of all physical science under the power of mathematical analysis, is the gradual development of connexions between the different members of that great group to which we give the name of physical science. And among the instances of such growing relationship I take, also suggested by the topics which have engaged us, the connexion between optics and chemistry. I only say "suggested" by our former subject, for I do not desire to attach any undue significance to the fact that of these connected sciences one may already be called a mathematical science. As yet the connexion between these sciences has consisted principally in the introduction into chemistry of an analysis in some respects more refined than any which has been hitherto known. And this fact does not in itself indicate the extension to chemistry of the mathematical character which belongs to physical optics. Still, if we hold the assumption of this character by any science to be the mark of perfection, we shall be inclined to regard every improvement in its instruments of research as tending in that direction.

In speaking of the connexion between Optics and Chemistry, the topic which will occur first to every one is the Spectroscope; but on this part of the subject it is not necessary that I should dwell. It has so largely occupied the attention of physicists, and has been so fully treated by those who have made it their special study, that I could not hope to add any thing to what they have said. I would only observe that the spectroscope has enabled chemistry to overleap a barrier

which Comte pronounced to be insurmountable, and which would have excluded from the objects of chemical research any thing lying without the limits of our earth. Comte warned us that our knowledge of the planetary worlds was necessarily limited to their geometrical and mechanical properties—to the nature of their movements, and the forces by which they are produced,—and that all inquiry into the constituent elements of the planets or their atmospheres was for ever, and by the necessities of the case, interdicted to us. But the spectroscope has told quite another story.

But there is another point of contact between optics and chemistry,—another spot on the border-land between these two sciences which, I think, promises also to be fertile in discovery,—I mean the use of polarized light as an instrument of chemical analysis. It is true that the application of this instrument is limited in its extent. The physical property on which this application depends (namely, the power possessed by certain liquids to change the plane of polarization of a transmitted ray, or, as it is commonly called, the rotatory power) is almost wholly confined to the organic world, and is not universal even there. Still, within this limited range, the application of polarized light is capable of solving, or aiding to solve, chemical problems which chemistry proper would probably find very difficult. Let me give you two examples.

1. Is it true that an acid salt is decomposed by solution? Or, taking the question in another form: If to a solution of a neutral salt there be added, atom for atom, a quantity of its own acid, does that additional atom of acid enter into combination, or does it remain free? It has been usually inferred from the thermic researches of Dr. Andrews, followed up by Favre, Silbermann, Berthelot, and others, that the second alternative is the true one, the solvent being water. Now, if the problem be varied a little by making the solvent spirit, the application of polarized light gives us this important information:—

If to an alcoholic solution of the ordinary nitrate of quinia there be added an additional equivalent of acid, this additional equivalent *does* enter into combination with the nitrate.

This information leaves to us the alternative of supposing that the ordinary nitrate, sulphate, &c. of quinia are not neutral but basic salts, or of admitting that an acid salt is not always decomposed by solution, at least in spirit.

2. When an acid is added to a solution containing two bases, the salts formed being also soluble, does the acid divide itself between the bases? and if so, what is the law which governs the division?

The application of polarized light enables us to solve this question for some of the organic bases, proving that there is a continuous partition of the acid, and enabling us in one case, and probably in many others, to assign the law according to which the partition is made.

One more instance may suffice to exemplify the advantage which chemistry proper has already derived from its union with optics. I take this instance from the general problem of saccharometry.

We have long known how to analyze, both optically and chemically, a solution containing two kinds of sugar, one of which is sucrose. But as each of these methods gives but two equations, it is plain that neither is sufficient where the unknown quantities are more than two. If, then, as is very commonly the case, there are present in the solution three kinds of sugar, we cannot obtain a complete analysis, either from optics or from chemistry. But, as Dr. Apjohn has recently shown, this problem, insoluble by either method taken alone, is readily solved by a combination of both methods. An important step is thus made in the application of optics to chemistry. Instead of merely giving to chemistry a new solution of a problem which chemistry could solve without any assistance, optics has aided chemistry to solve a problem which chemistry unaided might have found very difficult.

But it is time that I should bring these remarks to a close; and I recur, in conclusion, to a thought which my subject has already suggested.

Let none presume to fix the bounds of Science. "Hitherto shalt thou come, but no further"—that sentence is not for man. Not by our own powers, not by the powers of our generation, not even by our conceptions of possibility, may we limit the march of scientific discovery. To us, labourers in that great field, it is given

to see but a few steps in advance. And when at times a thicker darkness has seemed to gather before them, men have recoiled as from an impassable barrier, and for a while that path has been closed. But only for a while. Some happy accident, some more daring adventurer, it may be time itself, has shown that the darkness was but a cloud. The light of Science has pierced it; the march of Science has left it behind; and the impossibility of one generation is for the next but the record of a new triumph.

If seeming plausibility could give to man the right to draw across any path of scientific discovery an impassable line, surely Comte might be justified in the line which he drew across the path of chemistry. Fifty years ago it might seem no unjust restriction to say to the chemist, Your field of discovery lies within the bounds of our own earth. You must not hope to place in your laboratory the distant planet or the scarce-visible nebula. You must not hope to determine the constituents of their atmospheres as you would analyze the air which is around your own door; and you never will do it. Fifty years ago no chemist would have complained that chemical discovery was unjustly limited by such a sentence; perhaps no chemist would have refused to join in the prediction. Yet even those who heard it uttered have lived to see the prediction falsified. They have seen the barrier of distance vanish before the chemist, as it has long since vanished before the astronomer. They have seen the chemist, like the astronomer, penetrate the vast abyss of space and bring back tidings from the worlds beyond. Comte might well think it impossible. We know it to be true.

We have learned from this episode of scientific history that the attempt to draw an impassable line between the domain of the chemist and the domain of the astronomer was not justified by the result. Another generation may learn to obliterate as completely the line between the domain of the chemist and the domain of the mathematician. When that shall be, when Science shall have subjected all natural phenomena to the laws of Theoretical Mechanics, when she shall be able to predict the result of every combination as unerringly as Hamilton predicted conical refraction or Adams revealed to us the existence of Neptune—that we cannot say. That day may never come, and it is certainly far in the dim future. We may not anticipate it—we may not even call it possible. But not the less are we bound to look to that day, and to labour for it as the crowning triumph of Science, when Theoretical Mechanics shall be recognized as the key to every physical enigma—the chart for every traveller through the dark Infinite of Nature.

Mathematics.

On the General Equations of Chemical Decomposition. *By* Prof. W. K. Clifford, *F.R.S.*

On a Message from Professor Sylvester. *By* Prof. W. K. Clifford, *F.R.S.*

On certain Applications of Newton's Construction for the Disturbing Force exerted by a distant Body. *By* Professor Curtis.

The author remarked that the similarity between the expressions for the components, round the principal axes through the centre of gravity of a rigid mass A, of the moment due to the attraction of a distant body B and those for the components of the moment due to the centrifugal force arising from a rotation of A round an axis would naturally suggest a physical resemblance between the two; and he showed, from Newton's construction, that the couple exerted on A by the attraction of a distant body B, of mass L and at a distance a, is the same in magnitude as, and opposite in sign to, that which would result from the rotation of A, with an angular velocity ω, round a line in the direction of the distant body, and passing

through the centre of gravity of A, where ω is given by the equation $\omega^2=\frac{3L}{a^3}$. It was also shown that Newton's construction affords, in certain cases, an easy method of estimating the directive effect of one magnet on another.

On Statical and Kinematical Analogues. *By* Professor J. D. Everett.

If we take a line AB to represent a force along AB, the moment of this force round any point P will be represented by double the area of the triangle ABP.

If we take the same line AB to represent a velocity of rotation round AB, the same double area will represent the velocity of P due to this rotation.

We have thus a direct proof that a force acting along a line is the analogue of a velocity of rotation round it.

By supposing the line to be indefinitely distant, we obtain a couple as the analogue of a velocity of translation.

The moment of a force round a line is the analogue of the component velocity, along this line, of any point upon it; and the resultant moment round a point due to any combination of forces and couples is the analogue of the resultant velocity of a point due to any combination of velocities of rotation and translation.

In these statements, the moment of a force round a point is not regarded as a mere magnitude, but as a quantity having direction; in other words, as the moment of a couple whose plane passes through the point and the line of action of the force. The velocity which is the analogue of the moment will coincide in direction with the axis of this couple.

The only kinematical principles required for the demonstration of the above analogies are (1) the parallelogram of velocities for a particle, and (2) the proposition that the velocity of a point due to rotation round an axis is perpendicular to the plane of the point and axis, and proportional jointly to the angular velocity and the distance of the point from the axis.

On a New Application of Quaternions. *By* Professor J. D. Everett.

If ϖ denote a velocity of translation, regarded as a vector, and σ a velocity of rotation round the origin, represented by a vector drawn along its axis, we may write

$$\dot{\rho}=\varpi+V\sigma\rho, \qquad (1)$$

where $\dot{\rho}$ denotes the velocity of the particle whose vector is ρ. Hence the symbol

$$\varpi+V\sigma(\ \ ) \qquad (2)$$

is a complete representation of the velocity of a rigid body.

Again, if ϖ denote a couple (represented by its axis), and σ a force at the origin, the value of $\dot{\rho}$ in equation (1) is the resultant moment round the point whose vector is ρ. Hence the above expression (2) represents a system of forces acting on a rigid body.

The expression (2) affords remarkable facility for the discussion of such subjects as the composition of velocities of a rigid body, the general properties of systems of forces, the conditions of equilibrium of a rigid body under constraint, and the rate at which a system of forces does work upon a moving body.

The author is developing the method in a series of papers in the 'Messenger of Mathematics,' commencing with the Number for July 1874.

On Partitions and Derivations. *By* J. W. L. Glaisher, *M.A.*

It is well known that the number of partitions of n into the elements 1, 2, 3,.... (the *quotity* of n with respect to 1, 2, 3,.... according to Sylvester) is equal to the coefficient of x^n in the expansion of $\frac{1}{(1-x)(1-x^2)(1-x^3)\ldots}$; so that the theory

of partitions may be reduced to that of the expansion of algebraical fractions. In this way Cayley has regarded the question in his memoir in the Philosophical Transactions, 1856, p. 127, where, besides considering the general decomposition into partial fractions of the expression to be expanded, he has given the values of $P(1, 2)x$, $P(1, 2, 3)x, \ldots$, $P(1, 2, 3, 4, 5)x$, and in the Philosophical Transactions, 1858, p. 52, also of $P(1, 2, 3, 4, 5, 6)x$, $P(1, 2, 3, \ldots r)x$ denoting the number of ways of partitioning x into the elements $1, 2, 3, 4 \ldots r$. The subject is also considered by Sylvester (Quarterly Journal of Mathematics, vol. i. pp. 81 and 141, 1857), who likewise has treated it (though very differently) as an expansion problem. It may, however, be regarded in another light as follows:—

It is known that if we form the literal derivations of a power of a letter, say a^4, according to Arbogast's rule, viz.

$$\begin{array}{l} a^4, \\ a^3b, \\ a^3c,\ a^2b^2, \\ a^2d,\ a^2bc,\ ab^3 \\ a^2e,\ a^2bd,\ a^2c^2,\ ab^2c,\ b^4, \\ \ldots\ldots\ldots\ldots\ldots\ldots \end{array}$$

then each term corresponds to a partition; thus if $a=1$, $b=2, \ldots a^4$ corresponds to 1, 1, 1, 1, a^3b to 1, 1, 1, 2, the third line to 1, 1, 1, 3, and 1, 1, 2, 2, and so on, viz. we have the partitions into four parts of the numbers 4, 5, 6, ..., the $n+1$th line (the nth derivation) giving the partitions of $n+4$ into four parts. But by a known theorem the number of partitions of $n+r$ into r parts is equal to the number of partitions of n into the elements $1, 2, 3, \ldots r$. Thus the number of terms in the xth derivation of a^4 is equal to $P(1, 2, 3, 4)x$, and generally the xth derivation of a^n contains $P(1, 2, 3, \ldots n)x$ terms. From these considerations the value of $P(1, 2, 3, \ldots n)x$ can be found in the way which will now be briefly explained.

Consider a^2, and let 2^x denote the number of terms in the xth derivation; then, writing down a^2 and its first two derivations,

$$\begin{array}{l} a^2, \\ ab, \\ ac,\ b^2, \end{array}$$

we see that $2^2=1+2^0$, whence $2^{x+2}-2^x=1$; or writing u_x for 2^x and E for $1+\Delta$,

$$(E^2-1)u_x=1,$$

the solution of which, by the ordinary rules for the treatment of linear equations of differences with constant coefficients, is

$$u_x=\frac{x}{2}+A\alpha^x+B\beta^x,$$

where α and β are the square roots of unity. The complementary function can also be written in the far more convenient form $A+B(1, -1)\text{ per }2_x$, adopting Cayley's notation, in which $(A_0, A_1 \ldots A_{a-1})\text{ per }a$ denotes $A_0a_x+A_1a_{x-1}\ldots+A_{a-1}a_{x-a+1}$, a_x being a quantity which $=1$ when $x\equiv 0 \pmod{a}$, but which $=0$ in every other case, and the coefficients $A_0, A_1 \ldots A_a$, being such that for every factor b of a (including unity but excluding a itself), $A_0+A_b\ldots+A_{(c-1)b}=0$, $A_1+A_{b+1}\ldots+A_{(c-1)b+1}=0, \ldots A_{b-1}\ldots+A_{cb-1}=0$, where $bc=a$, and for the case of $b=1$, $A_0+A_1\ldots+A_{a-1}=0$. Determining, then, the constants from the conditions $2^0=1$, $2^1=1$, we find

$$2^x=P(1, 2)x=\tfrac{1}{4}\{2x+3+(1, -1)\text{ per }2_x\}.$$

Now consider a^3, and let 3^x denote the number of terms in its xth derivation; then, by writing down the first three derivations of a^3, we see that $3^3=1^2+2^1+3^0$; so that $3^{x+3}-3^x=1+2^{x+1}$, and the equation of differences is

$$(E^3-1)u_x=\tfrac{1}{4}\{2x+9+(1, -1)\text{ per }2_{x+1}\}.$$

The complementary function here is $A\alpha_1^x+B\beta_1^x+C\gamma_1^x$, $\alpha_1, \beta_1, \gamma_1$ being the cube roots of unity; and it is to be observed that we can easily express it in Cayley's form as a prime circulator, for it may obviously be written in the form $A3_x+B3_{x-1}+C3_{x-2}$, viz. (A, B, C) circlor 3_x. And since $3_x+3_{x-1}+3_{x-2}$ is constant (*i. e.* independent of x), we can always, by assigning a proper value to the constant term, make $A+B+C=0$, and so take the complementary function to be P+(Q, R, S) pcr 3_x, where P, Q, R, S are to be determined by the conditions $3^0=1, 3^1=1, 3^2=2$. For the particular integral we find

$$u_x=\tfrac{1}{4}\cdot\frac{1}{E^3-1}(2x+9)+\tfrac{1}{4}\cdot\frac{1}{E^3-1}(1,-1)\text{ pcr }2_{x+1}.$$

The first term is readily obtained in the ordinary way by replacing E by $1+\Delta$ and expanding in ascending powers of Δ; and the second term

$$=\tfrac{1}{4}\cdot\frac{1}{E^3-1}\{(\alpha-1)\frac{\alpha^x}{2}+\text{similar function of }\beta\}$$

$$=\tfrac{1}{4}\cdot\frac{\alpha-1}{\alpha^3-1}\cdot\frac{\alpha^x}{2}+\text{similar function of }\beta$$

$$=\tfrac{1}{4}\left(\frac{\alpha^x}{2}+\frac{\beta^x}{2}\right)=\tfrac{1}{4}(1,0)\text{ circlor }2_x=\tfrac{1}{8}(2,0)\text{ circlor }2_x,$$

which differs only from $\frac{1}{8}(1,-1)$ pcr 2_x by a constant (viz. $\frac{1}{8}$). Thus we have

$$3_x=P(1,2,3)x=\tfrac{1}{72}\{6x^2+36x+P+9(1,-1)\text{ pcr }2_x+(Q,R,-Q-R)\text{ pcr }3_x\};$$

and by putting $x=0, 1, 2$, we find $P=47$, $Q=16$, $R=-8$, agreeing with Cayley's result.

From the derivations of a^4 we find $4^4=1^3+2^2+3^1+4^0$; so that the differential equation is

$$\begin{aligned}(E^4-1)u_x&=3^{x+1}+2^{x+2}+1\\&=\tfrac{1}{72}\{6x^2+84x+287+18(1,-1)\text{ pcr }2_{x+2}+9(1,-1)\text{ pcr }2_{x+1}\\&\quad+8(2,-1,-1)\text{ pcr }3_{x+1}.\end{aligned}$$

The complementary function is (A, B, C, D) circlor 4_x, which a little consideration shows may be written in the form $P+(Q,-Q)$ pcr $2_x+(R, S,-R,-S)$ pcr 4_x; so that in finding the particular integral we are not to calculate the terms of the form $P+(Q,-Q)$ pcr 2_x. The algebraical part of the particular integral is easily found, by operating on the first three terms with $(E^4-1)^{-1}$, to be $\frac{1}{288}(2x^3+30x^2+135x)$. The terms with period 2 (omitting the coefficient $\frac{9}{72}$) give

$$\frac{1}{E^4-1}(2a^2-2a+a-1)\frac{a^x}{2}+\&c.=\frac{2a^2-a-1}{a^4-1}\frac{a^x}{2}+\&c.,$$

which takes the form ∞; so that we have a term included in the complementary function + term found by differentiating the numerator and denominator, the latter being

$$=x\frac{2a-1-a^{-1}}{4a^3}\frac{a^x}{2}+\&c.=x\frac{1-a^{-1}}{4}\cdot\frac{a^x}{2}+\&c.=\frac{x}{4}(1,-1)\text{ pcr. }2_x.$$

The term with period 3 gives

$$\frac{2a_1-1-a_1^{-1}}{a_1^4-1}\frac{a_1^x}{3}+\&c.=\frac{2a_1-1-a_1^{-1}}{a_1-1}\frac{a_1^x}{3}+\&c.=(2+a_1^{-1})\frac{a_1^x}{3}+\&c.$$

$$=(2,1,0)\text{ circlor }3_x=\text{const}+(1,0,-1)\text{ pcr }3_x.$$

Thus

$$\begin{aligned}4^x=P(1,2,3,4)x=\tfrac{1}{288}\{&2x^3+30x^2+135x+P+(9x+Q)(1,-1)\text{ pcr }2_x\\&+32(1,0,-1)\text{ pcr }3_x+(R,S,-R,-S)\text{ pcr }4_x\};\end{aligned}$$

and since $4^0=1, 4^1=1, 4^2=2, 4^3=3$, by making $x=0, 1, 2, 3$, we find $P=175, Q=45$, $R=36$, and $S=0$, agreeing with Cayley's value.

The general method of treatment is now clear, and it is unnecessary in this abstract to proceed further. Thus for 5^x we should have the relation $5^5=1^4+2^3+3^2+4^1+5^0$, the law being evident; and it will have been seen that by the use of prime circulators (in which the sum of the coefficients is zero) the result is exhibited in the most convenient form, as when so expressed it may be written $(A+B\omega^{-1}+C\omega^{-2}+\ldots.)\omega^x+\&c.$, ω being an nth root of unity; and the operation $(E^{n+1}-1)^{-1}$ is performed at once on the circulator as it stands, since $\omega-1$ is a factor of the coefficient of ω^x. It will also be remarked that we can always express $(A_0, A_1, \ldots. A_{a-1})$ circlor a_x as a series of prime circulators, one for each factor of $a-$ having the same number of constants; and that whenever the complementary function so expressed contains a term identical in form with one which already appears in the equation of differences, we shall (as is known from the theory of such equations) have to expand or differentiate, and so obtain a term with a new form of coefficient to the same prime circulator. Since $n^n=1^{n-1}+2^{n-2}\ldots.+n^0$, we see that, to determine the partitions of x into the n elements $1, 2, \ldots. n$, we should require to substitute the values of $(n-1)^{x+1}, (n-2)^{x+2} \ldots. 2^{x+n-2}$; so that if n were large the work would be laborious.

There is an interesting class of questions which arise in connexion with Arbogast's derivations, and which admit of solution by the principles explained above. If we consider, for example, the second derivation of a^4, viz. a^3c and a^2b^2, we notice that a^3c in any succeeding derivation can never give rise to more than one term, while a^2b^2 gives rise to a^2bc and ab^3. The terms in any derivation therefore are of two kinds, viz. are (1) extinct or sterile terms which merely continue to give rise in each derivation to one term of the same type as themselves, or (2) active or prolific terms which will give rise to two terms in some subsequent derivation. Thus in the fourth derivation of a^4 the active terms are a^2c^2, ab^2c, and b^4, while a^2e and a^2bd are extinct. In fact all terms are extinct except those in which the last letter is raised to a power, or in which the last two letters are consecutive.

Suppose it now required to find the number of extinct terms in the xth derivation of a^2; let 2^x denote this number, then, as before, $2^2=1^1+2^0$ and $2^{x+2}-2^x=1$, but here $2^0=0$ and $2^1=0$. Solving and determining the constants, we have

$$2^x=\tfrac{1}{4}\{2x-1+(1,-1)\text{ per }2_x\}.$$

Let 3^x denote the number of extinct terms in the xth derivation of a^3, then $3^3=1^2+2^1+3^0$, and the equation of differences is

$$3^{x+3}-3^x=\tfrac{1}{4}\{2x+5+(1,-1)\text{ per }2_{x+1}\};$$

whence, by integrating and determining the constants from the conditions $3^0=0$, $3^1=0$, $3^2=1$,

$$3^x=\tfrac{1}{72}\{6x^2+12x-1+9(1,-1)\text{ per }2_x+8(-1,-1,2)\text{ per }3_x\}.$$

If 4^x denote the number of extinct terms in the xth derivation of a^4, we have $4^{x+4}-4^x=1+2^{x+2}+3^{x+1}$

$$=\tfrac{1}{72}\{6x^2+60x+143+9(2a^2-a-1)\frac{a^x}{2}+\&c.+8(-a_1-1+2a_1{}^{-1})\frac{a_1{}^x}{3}+\&c.\},$$

whence

$$4^x=\tfrac{1}{288}\{(\Sigma-\tfrac{3}{2}+\tfrac{5}{4}\Delta)(6x^2+60x+143)+36x\frac{2a-1-a^{-1}}{4a}\frac{a^x}{2}+\&c.$$
$$+32(-1-2a_1{}^{-1})\frac{a_1{}^x}{3}+\&c.+\text{compl. funct.}\}$$
$$=\tfrac{1}{288}\{2x^3+18x^2+39x+9x(1,-1)\text{ per }2_x+32(-1,-2,0)\text{ circlor }3_x+A$$
$$+B(1,-1)\text{ per }2_x+(C, D, -C, -D)\text{ per }4_x\}.$$

On replacing $32(-1,-2,0)$ circlor 3_x by $32(0,-1,1)$ per 3_x (which only alters the value of A) and determining the constants by the conditions $4^0=0$, $4^1=0$, $4^2=1$, $4^3=1$, we find

$$\begin{aligned}4^x=\tfrac{1}{288}\{2x^3+18x^2+39x+9&+(9x+27)(1,-1)\text{ per }2_x\\&+32(-0,-1,1)\text{ per }3_x\\&+36(-1,0,1,0)\text{ per }4_x\}.\end{aligned}$$

We may also investigate the number of active quadratic, cubic, &c. terms in any derivation. Such a term as a^2bc is a quadratic term, as its derivations are found exactly as if a^2 were absent; ab^3 is a quartic term, as also is a^2b^2; but ab^2c is a cubic term, and so on. (Viewed in this manner extinct terms are merely linear terms.) The equation $n^n=1^{n-1}+2^{n-2}\ldots+(n-1)^1+n^0$ always holds good whenever n^x denotes the number of terms of any defined class in the xth derivation of a^n; so that the equations of differences are always of the same form, the alterations depending on the different values assigned to the constants. The number of quadratic terms in the xth derivation of a^2 is of course 1; in the xth derivation of a^3 it is found to be $\frac{1}{3}\{x-1+(1,0,-1)\text{ per }3_x\}$, and so on. The xth derivation of a^3 contains only one cubic term; and as a verification we notice that $1+$ the expression just written down $+$ the number of extinct terms found previously, $=P(1,2,3)x$, as it should be.

On some Elliptic-transcendent Relations. By J. W. L. GLAISHER, *M.A.*

The author remarked that every integral of the form $\int_0^\infty \phi(x)\cos nx\,dx$, ϕx being an even function, gave rise to a series such as

$$\phi(x)-\phi(x-a)-\phi(x+a)+\phi(x-2a)+\phi(x+2a)-\ldots=A_1\cos\frac{\pi x}{a}+A_3\cos\frac{3\pi x}{a}+\ldots$$

(see Quarterly Journal, vol. i. p. 316). In this way Sir W. Thomson deduced the theorem

$$e^{-x^2}-e^{-(x-a)^2}-e^{-(x+a)^2}+e^{-(x-2a)^2}+e^{-(x+2a)^2}-\ldots$$
$$=\frac{2\sqrt{\pi}}{a}\left\{e^{-\frac{\pi^2}{4a^2}}\cos\frac{\pi x}{a}+e^{-\frac{9\pi^2}{4a^2}}\cos\frac{3\pi x}{a}+\ldots\right\},$$

which, as was noticed by Cayley, is only another form of

$$\Theta(ui)=\sqrt{\left(\frac{K}{K'}\right)}e^{-\frac{\pi u^2}{4KK'}}H(u+K',k').$$

The number of integrals of the above form that have been evaluated is not large, but all that there are appear to give elliptic-transcendent formulæ. An interesting example is the integral

$$\int_0^\infty\frac{\cos rx}{e^{nx}+e^{-nx}}dx=\frac{\pi}{2n}\frac{1}{e^{\frac{r\pi}{2n}}+e^{-\frac{r\pi}{2n}}},$$

which, as will be seen, may be regarded as a transformation of

$$\cos\text{am }u=\frac{1}{\cos\text{am }(ui,k')}.$$

The integral can be written

$$\int_{-\infty}^{\infty}\frac{\cos\frac{r\pi x}{a}}{e^{nx}+e^{-nx}}dx=\frac{\pi}{n}\frac{1}{e^{\frac{r\pi^2}{2an}}+e^{-\frac{r\pi^2}{2an}}},$$

whence, by dividing the course integrated over into parts each equal to a,

$$\frac{1}{e^{nx}+e^{-nx}}-\frac{1}{e^{n(x-a)}+e^{-n(x-a)}}-\frac{1}{e^{n(x+a)}+e^{-n(x+a)}}+\ldots$$

$$=\frac{2\pi}{an}\Sigma_0^\infty\frac{\cos\frac{(2r+1)\pi x}{a}}{e^{\frac{(2r+1)\pi^2}{2an}}+e^{-\frac{(2r+1)\pi^2}{2an}}}.$$

Now take $x=\frac{au}{2\mathrm{K}}$, $a=\frac{\pi\mathrm{K}}{n\mathrm{K}'}$, so that $nx=\frac{\pi u}{2\mathrm{K}'}$, then

$$\frac{1}{e^{\frac{\pi u}{2\mathrm{K}'}}+e^{-\frac{\pi u}{2\mathrm{K}'}}}-\frac{1}{e^{\frac{\pi}{2\mathrm{K}'}(u-2\mathrm{K})}+e^{-\frac{\pi}{2\mathrm{K}'}(u-2\mathrm{K})}}-\frac{1}{e^{\frac{\pi}{2\mathrm{K}'}(u+2\mathrm{K})}+e^{-\frac{\pi}{2\mathrm{K}'}(u+2\mathrm{K})}}+\ldots$$

$$=2\frac{\mathrm{K}'}{\mathrm{K}}\Sigma\frac{\sqrt{q^{2r+1}}}{1+q^{2r+1}}\cos\frac{(2r+1)\pi u}{2\mathrm{K}} \quad \ldots\ldots\ldots \quad (1)$$

By well-known formulæ we have

$$\cos\operatorname{am} u=\frac{2\pi}{k\mathrm{K}}\Sigma\frac{\sqrt{q^{2r+1}}}{1+q^{2r+1}}\cos\frac{(2r+1)\pi u}{2\mathrm{K}}$$

$$\sec\operatorname{am}(u,k')=\frac{\pi}{2k\mathrm{K}'}\left\{\sec\frac{\pi u}{2\mathrm{K}'}-\frac{4t}{1+t}\cos\frac{\pi u}{2\mathrm{K}'}+\frac{4t^3}{1+t^3}\cos\frac{3\pi u}{2\mathrm{K}'}-\ldots\right\},$$

where $t=e^{-\frac{\pi\mathrm{K}}{\mathrm{K}'}}$; whence

$$\sec\operatorname{am}(ui,k')=\frac{\pi}{k\mathrm{K}'}\left\{\frac{1}{e^{\frac{\pi u}{2\mathrm{K}'}}+e^{-\frac{\pi u}{2\mathrm{K}'}}}-\left(e^{\frac{\pi u}{2\mathrm{K}'}}+e^{-\frac{\pi u}{2\mathrm{K}'}}\right)(t-t^2+t^3-\ldots)\right.$$

$$\left.+\left(e^{\frac{3\pi u}{2\mathrm{K}'}}+e^{-\frac{3\pi u}{2\mathrm{K}'}}\right)(t^3-t^6+t^9-\ldots)-\&c.\right\}$$

$$=\frac{\pi}{k\mathrm{K}'}\left\{\frac{1}{e^{\frac{\pi u}{2\mathrm{K}'}}+e^{-\frac{\pi u}{2\mathrm{K}'}}}-\frac{te^{\frac{\pi u}{2\mathrm{K}'}}}{1+t^2e^{\frac{\pi u}{\mathrm{K}'}}}-\frac{te^{-\frac{\pi u}{2\mathrm{K}'}}}{1+t^2e^{-\frac{\pi u}{\mathrm{K}'}}}+\ldots\right\}$$

$$=\frac{\pi}{k\mathrm{K}'}\left\{\frac{1}{e^{\frac{\pi u}{2\mathrm{K}'}}+e^{-\frac{\pi u}{2\mathrm{K}'}}}-\frac{1}{te^{\frac{\pi u}{2\mathrm{K}'}}+t^{-1}e^{-\frac{\pi u}{2\mathrm{K}'}}}-\frac{1}{te^{-\frac{\pi u}{2\mathrm{K}'}}+t^{-1}e^{\frac{\pi u}{2\mathrm{K}'}}}+\ldots\right\};$$

so that (1) is the identical relation that results from equating the series for $\cos\operatorname{am} u$ and $\sec\operatorname{am}(ui,k')$.

Contributions to the Report on Mathematical Tables.
By Professor Bierens de Haan.

This important communication, which will form part of a future Report of the Committee on Mathematical Tables, consisted of three catalogues—the first and second containing descriptions of 128 logarithmic and 105 non-logarithmic tables from actual inspection, and the third being a list of 553 logarithmic tables, with the date, size, place, author's name, and number of decimals as far as known, being a development of a similar list of 267 tables published by Prof. de Haan in 1862.

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*On some Conversions of Motion**.

By H. Hart, *M.A., late Fellow of Trinity College, Cambridge.*

1. The positive and negative Peaucellier cells may be combined together by the addition of two extra bars to either, thus making a complete double cell composed of two rhombs jointed together, giving four points, A, a, β, B, lying always in a straight line—a, β being the poles, A or B the fulcrum of a positive, and A, B being the poles, a or β the fulcrum of a negative Peaucellier cell. Thus each cell has two fulcra as well as two poles, the convenience of the second fulcrum being manifest in the tracing of certain discontinuous curves. As an example, let A, B be the poles, a, β the fulcra of a negative cell, A′, B′, a', β' the poles and fulcra of an exactly similar cell, c^2 being the modulus of either.

Let A, B′ be fixed and A′, B be connected by a bar whose length $2b=AB'$. Let the fulcra β, β' be fixed together. Then if c be $> b$, β will trace out the *continuous* oval of Cassini, but if c be $< b$, β will trace out an oval surrounding B; if β, β' be set free, and a, a' fixed, this point a will trace out the conjugate round A. A similar statement may be made with regard to the positive cell.

N.B. While β traces the Cassinian, a and a' trace out a certain Cartesian†.

2. If four bars, AD, BC, AB, CD, equal two and two, be jointed so as to form the equal diagonals and equal but not parallel sides of a trapezium ABDC, and if QPP′Q′ be a straight line parallel to AC or BD, cutting the four bars above in the points P, P′, Q, Q′ respectively, then these points are such that

$$QP,\ QP'=Q'P,\ Q'P'=PQ,\ PQ'=P'Q,\ P'Q'=\text{constant};$$

hence Q, P, P′, Q′ are equivalent to the four points A, a, β, B of the completed Peaucellier cell described above. By means of the above system of four bars it is evident that, by the addition of a bar which causes P or P′ to move in a circle passing through Q or Q′, we make P′ or P move in a straight line. This contradicts the statement made (I believe) by Professor Tchebicheff, that seven bars at least are requisite for the conversion of circular into rectilinear motion.

3. If, further, one of the four bars, say AD, be fixed, then the point on the bar which is equal to the one fixed describes the inverse of a conic; for if $AD=BC=2a$, $AB=CD=2b$, and c=the distance of the fixed point P from the centre of the bar AD, it is easily seen that the equation to the locus of P′ is

$$4b^2-4a^2\sin^2\theta=\{\rho-2c\cos\theta\}^2,$$

which, when inverted and transformed to Cartesian coordinates, becomes

$$(b^2-c^2)x^2+(b^2-a^2)y^2+2c\kappa^2x=\kappa^4 \ (2\kappa^2 \text{ being the modulus}).$$

4. Professor Sylvester (to whom I am indebted for various suggestions and remarks connected with this paper) has shown that three points otherwise free may be made collinear by the use of fifteen bars; by help of the above trapezium motion n points may be made collinear by the use of $5n-4$ bars.

If AOA′ be three points always collinear, and AA′ be moreover the angular points of a rhomb APAP′, whose sides are of any constant length, then OP′ must always =OP. Hence any number of points otherwise free may be caused always to lie on a sphere of variable radius.

5. Let A, B, C be three points constrained to move along three axes, Ox, Oy, Oz; let the points A, B be connected by a pantigraph so that a point E always bisects AB; let D be connected with O by another pantigraph, so that the middle point of OD coincides with E: then OADB is always a parallelogram in the plane xOy. In a similar manner let a parallelogram CODP be constructed; then OA, OB, OC are the coordinates of P.

Let another series of pantigraphs determine a point P′ from OA′, OB′, OC′, and let A, A′, &c. be connected in such a manner that

$$OA=f(OA'),\ OB=\phi(OB'),\ OC=\psi(OC'),$$

* For the paper *in extenso*, see 'Messenger of Mathematics,' No. 42, New Series.

† Its equation is of the form $r_2=\mu\rho$, r and ρ being vectorial coordinates.

$f(u)$, $\phi(u)$, $\psi(u)$ being any three kinematical functions of u; then, if P move on the surface

$$F(x, y, z)=0,$$

P′ moves on the surface

$$F\{f(x), \phi(y), \psi(z)\}=0.$$

Ex. Let P be capable of motion in the plane

$$lx+my+nz=p.$$

(i) Let $f(u)=u^2=\phi(u)=\psi(u)$, then P′ describes the central conicoid

$$lx^2+my^2+nz^2=p.$$

(ii) Let $f(u)=u^2=\phi(u)$, $\psi(u)=u$, then P′ describes the paraboloid

$$lx^2+my^2+nz=p.$$

There are more simple methods for the description of conicoids, but these are mentioned as examples of the general method given above.

(iii) In two dimensions we can obtain the unicursal quartics from conics by putting $f(u)=\phi(u)=\frac{1}{u}$ (Salmon's 'Higher Plane Curves,' art. 283).

(iv) By putting $f(u)=u^2=\phi(u)=\psi(u)$, we can describe the wave-surface from a surface of the second degree.

6. Let O_1, O_2, O_3 be three points fixed in space, and P_1, Q_1, P_2, Q_2, P_3, Q_3 six points connected with them in such a manner that O_1, P_1, Q_1 are collinear, and

$$O_1P_1=f_1(O_1P_1),$$
$$\text{or } \rho_1=f_1(r_1),$$
$$\text{also } \rho_2=O_2P_2=f_2(O_2Q_2)=f_2(r_2),$$
$$\rho_3=O_3P_3=f_3(O_3Q_3)=f_3(r_3),$$

$f_1(u)$, $f_2(u)$, $f_3(u)$ being kinematical functions of u; and let R_1, R_2, R_3 be three points such that $O_1R_1=O_1Q_1$, $O_2R_2=O_2Q_2$, $O_3R_3=O_3Q_3$.

Then, if P_1, P_2, P_3 be connected, and also R_1, R_2, R_3, it follows that if the P point be constrained to move on the surface

$$F(\rho_1, \rho_2, \rho_3)=0,$$

the R point moves on the surface

$$F\{f_1(r_1), f_2(r_2), f_3(r_3)\}=0.$$

Ex. Let P move on the sphere

$$a\rho_1{}^2+b\rho_2{}^2+c\rho_3{}^2=d^3.$$

(i) Let $f_1(u)=\sqrt{u}=f_2(u)=f_3(u)$, then R describes the surface

$$ar_1+br_2+cr_3=d^3.$$

If the motion be in two dimensions, we thus obtain a method for describing the Cartesian ovals, and by inverting these we have bicircular quartics and circular cubics (Salmon's 'Higher Plane Curves,' art. 281).

(ii) If $f_1(u)=\frac{1}{\sqrt{u}}=f_2(u)=f_3(u)$,

R describes the equipotential surfaces for three electrified points.

On Approximate Parallel Motion. *By* W. HAYDEN.

On the Application of Kirchhoff's Rules for Electric Circuits to the Solution of a Geometrical Problem. *By* Prof. CLERK MAXWELL, *M.A., F.R.S.*

The geometrical problem is as follows:—

Let it be required to arrange a system of points so that the straight lines joining

them into rows and columns shall form a network such that the sum of the squares of all these joining lines shall be a minimum, the first and last points of the first and the last row being any four points given in space. The network may be regarded as a kind of extensible surface, each thread of which has a tension proportional in each segment to the length of the segment.

The problem is thus expressed as a statical problem, but the direct solution would involve the consideration of a large number of unknown quantities.

This number may be greatly reduced by means of the analogy between this problem and the electrical problem of determining the currents and potentials in the case of a network of wire having square meshes, one corner of the network being kept at unit potential while that of the other three corners is zero.

This problem having been solved by Kirchhoff's method, the position of any point P in the geometrical problem, with reference to the given points A, B, C, D, is determined by finding the values of the potentials p_a, p_b, p_c, p_d of the corresponding point in the electric problem when the corners a, b, c, d respectively are those of unit potential.

The position of P is then found by supposing masses p_a, p_b, p_c, p_d placed at A, B, C, D respectively, and determining P as the centre of gravity of the four masses.

On the Calculation of Exponential Functions. By Prof. F. W. Newman.

This paper consisted of certain tables of e^{-x}, with an account of the mthod of their construction. The author placed them at the disposal of the Committee on Mathematical Tables, that they might be used to supplement or verify the tables of e^{-x} mentioned in the Committee's Report (Brit. Assoc. Report, 1873, pp. 2 and 167).

On Bitangents to the Surface of Centres of a Quadric. By Prof. F. Purser.

On Multiple Contact of Quadrics and other Surfaces. By W. Spottiswoode, *M.A., F.R.S.*

Explanations of Mr. M'Clintock's Method of finding the Value of Life Annuities by means of the Gamma Function. By T. B. Sprague, *M.A.*

Astronomy.

Photographic Operations connected with the Transit of Venus. By Capt. Abney, *R.E., F.R.A.S., F.C.S.*

In this paper an account was given by the author of the means adopted for insuring, at the different stations which would be occupied by the parties sent out to observe the transit of Venus, photographic observations of the phenomenon in question. It had been determined that at every station a photograph should be taken every two minutes during the transit, and it has been a matter of considerable labour to work out a process that would admit of such a large number of negatives being taken in a hot climate. In Kerguelen's Land it would be perfectly feasible to adopt the ordinary wet process, the low temperature admitting of it; but in a temperature of 90° F. the evaporation of the volatile constituents of the collodion would render such a process inapplicable, as all photographers will admit. In India, where the author had worked, a large-sized tent had often proved injurious, and it would have been madness to have trusted to the wet method. It was therefore determined to use a dry process if practicable; and after much deliberation it was decided to employ an albumen dry process, using a

highly bromized collodion and strong alkaline development. The author gave an account of the advantages thus secured, and discussed how each could be best obtained, especially alluding to the phenomenon of irradiation. He mentioned that at each station the photographic party would consist of one officer and three sappers all well trained to the process, so that all excitement at the critical moment might be avoided. Practice on the mock transit at Greenwich has given them a thorough knowledge of each phase of the phenomenon.

On the Spectrum of Coggia's Comet. By W. Huggins, *D.C.L., F.R.S.*

Preliminary Note on Coggia's Comet. By J. N. Lockyer, *F.R.S.*

Preliminary Note on a New Map of the Solar Spectrum. By J. N. Lockyer, *F.R.S.*

On Photography in Connexion with Astronomy. By Col. Stuart Wortley.

Having been asked by the Astronomer Royal for some information in connexion with photographic processes with a view to their being used for the transit of Venus, and having had the advantage of discussion of the various processes with my friend Captain Abney, who has been in charge of the transit photographic work, I made at various times during the past summer a number of experiments in solar photography, the result of which may possibly be of use to future workers in this branch of science.

Taking the ordinary commercial collodions manufactured for photographic processes, we are at once struck with the difficulty of getting accurate micrometrical measurements, in consequence of the varying amount of contraction and expansion possessed by the collodion-film in its wet and dry states. To counteract this difficulty it is necessary to make the pyroxyline with the maximum of water added to the acids which they will bear without dissolving the cotton when immersed therein; and it is also desirable to reduce considerably the proportion of nitric acid to sulphuric, with the object of obtaining a film which shall neither contract nor expand when either wet or dry. By using such a pyroxyline I have been enabled to make a film on which the most delicate micrometrical measurements can be registered with absolute perfection.

The next point to be considered in connexion with astronomical photography is the radiation and halation produced where the bright and dark parts of the picture meet. This appears to proceed from two different causes—one, which we may call "halation," being the reflection of light back from the glass which supports the film into the film itself; and the other, which I will call "radiation," appears to be an action in the sensitive molecules of the film itself, and occurs no matter on what support the film may be laid. Halation from the first of these two causes can be prevented in two ways—one method being to place a dark pigment on the back of the glass plate and in optical contact therewith; and the other, and far preferable one, to stain or dye the film itself with such an amount of orange or red colour as shall stop the rays of light from getting down to the glass and being thence reflected.

But the radiation which takes place in the film itself is much more difficult to subdue, cannot be subdued by mechanical means, and can only be subdued by the use of certain chemicals in the film, differing somewhat from those in use in the ordinary photographic processes.

Before pointing out what I consider the best means of avoiding this injurious halation I will point out what I consider it to be, and why I consider it to be so. I think the radiation in photographic films, which is so unpleasantly apparent when a bright object is photographed in close proximity to a dark one, is due to what I may call a "creeping" of the superabundant light, which has done its work on the bright

object, over and into the darker portions of the picture. To illustrate this argument the following fact in connexion with dry-plate photography should be borne in mind:—If a landscape photograph consisting of trees and sky be taken in a bright and actinic light, and when a short exposure is therefore only necessary, there will be on a rapid dry plate but little radiation; but if the same view be taken in a dull light, and when the actinism is infinitely less, the longer exposure required will certainly produce a great amount of radiation from the sky over the trees: now the sky, even in a dull light, would be impressed on the film tolerably rapidly, and the necessity for the long exposure is in order to get the detail in the darker parts of the picture; and the radiation is thus produced by the creeping of the superabundance of light that has already finished its work on the sky over the dark parts of the picture, which require the prolonged exposure. That this "creeping of the light" does take place, the following experiment will, I think, show with certainty.

In order to find out which of the salts of silver were least liable to give this radiation I have experimented with a very large number of them, to which I will presently allude; and the following singular fact was discovered by me in connexion with the chloride of silver, which salt has much more tendency to give radiation than any other that I have experimented with. I had found that a sensitive film which contained a chloride was always possessed of less satisfactory keeping qualities than one from which chloride was absent; and in course of some experiments on the various keeping qualities of plates between exposure and development the following observations were made:—A dry film containing a considerable quantity of chloride was after exposure cut in half; one half developed immediately, and the other half put away in the dark for forty-eight hours. It was found that on the half of the plate that had been kept in the dark for forty-eight hours the "blurring," as it is called by photographers, was considerably greater than on the half plate that was developed at once; and on repeating the experiment several times I was enabled to convince myself that the action of radiation, or what I have called the "creeping of light" on to the dark parts of the picture, continues after the film has been removed from the action of the light, and after it has been put away in the dark. I have noticed this with chloride of silver only, but I was thus led to investigate the behaviour of other salts of silver in connexion with this radiation of light.

No photographic process gives such good and rapid dry plates as the one in which an emulsion is made of bromide of silver formed in the presence of a large excess of the nitrate of the metal; but when we use the bromide alone it is unfortunately strongly addicted to the blurring before spoken of. We can, however, entirely counteract this tendency by the use of other salts of silver. I will not take up your time by going into very minute details on this point, but will merely say that I have found that the addition either of the malate, succinate, fluoride, or iodide of silver to the bromide will, if used in the proper proportion, give a sensitive film from which radiation shall be entirely absent, and that their suitability to the purpose is found in the order in which I have written their names; and with a film containing a large proportion of malate of silver I have been enabled to take subjects which it would be impossible to take by any other method, owing to their strong contrasts of black and white. It should also be noticed that these salts have a peculiar effect on the colour of the finished negative—the malate giving a golden brown, the succinate a red-brown, the fluoride a pink, and the iodide a delicate green. It is also a great preventive of radiation to add nitrate of uranium to the emulsion, and whatever other salts are used this should never be omitted. I may also mention here that I have found these various salts to act in a remarkable manner in connexion with the colours of the spectrum, and to give peculiar results in connexion with some of the more difficult lines thereof.

There is one final point as to the obtaining of good astronomical photographs. It appears to me to be essential that they should be developed by the strong alkaline method of development which was introduced by myself in the course of last year. It is impossible with the old method of development to obtain results in any way as satisfactory as those obtained by my new method. Not only is there a very great increase of sensitiveness obtained, but the development is unusually certain and rapid, and where the sun has to be photographed it has a peculiar effect in giving

the outer limb clear and sharp. Captain Abney has, after many experiments, decided on using my method of development for the dry plates used at the transit of Venus, the formula being a saturated solution of carbonate of ammonia with sufficient pyrogallic acid, and bromide of potassium if required.

Physics.

On Experiments at High Pressures. By Prof. T. Andrews, *F.R.S.*

On the Teaching of Practical Physics. By Prof. W. F. Barrett.

On the Physical Theory of Undercurrents. By W. B. Carpenter, *M.D., F.R.S.*

On the Flight of Birds. By Prof. F. Guthrie, *F.R.S.*

Confirmation of the Nebular Origin of the Earth. By G. Johnstone Stoney, *F.R.S.*

On the Physical Units of Nature. By G. Johnstone Stoney, *F.R.S.*

Physics of the Internal Earth. By Dr. Vaughan.

Heat.

On the Latent Heat of Gases. By J. Dewar, *F.R.S.E.*

On a New Class of Hydrates. By Prof. F. Guthrie, *F.R.S.*

On the Source from which the Kinetic Energy is drawn that passes into Heat in the Movement of the Tides. By John Purser, *M.A., M.R.I.A., Professor of Mathematics in Queen's College, Belfast.*

Attention has of late years been directed, by Mayer, James Thomson, and others, to the fact that the friction of the tidal currents on the bed of the ocean exercises an effect in retarding the earth's rotation on its axis. The late astronomer Delaunay showed that such effect was appreciable, and that it furnished a not improbable cause of the unexplained part of the secular inequality in the moon's mean motion.

He pointed out that inasmuch as the axis of the tidal spheroid is always behind the moon's place, a couple is exerted by the forces of the moon's attraction, which, on the one hand, retards the rotation of the earth, and on the other, by its reciprocal action, increases the dimensions of the lunar orbit.

This alteration of the lunar orbit prevents us concluding, as we should otherwise do, that the kinetic energy which passes into heat in the movement of the tides has for its exact equivalent a corresponding quantity drawn from the store laid up in the earth's rotation on its axis.

The object of the present paper is to examine whether we can assert such an equivalence to hold approximately, and if so, to what degree of approximation.

The question was started some years ago by the Astronomer Royal in the 'Astronomical Notices.'

In the course of a discussion of M. Delaunay's views, he proceeds to remark:—"It will probably be difficult to say what is the effect of friction in more complicated cases. Conceive, for instance (as a specimen of a large class), a tide-mill for grinding corn. The water which has been allowed to rise with the rising tide is not allowed to fall with the falling tide; but after a time is allowed to fall, thereby doing work and producing heat in the meal formed by grinding the corn. I do not doubt that this heat is the representative of *vis viva* lost somewhere; but whether it is lost in the rotation of the earth or in the revolution of the moon, I am quite unable to say."

It occurred to me that considerable light might be thrown upon the whole subject by combining the equation of energy with that of the conservation of angular momentum.

Let us first suppose the case of a binary system, consisting of the earth and moon, the orbit of the latter being supposed to coincide with the earth's equator.

Let Q denote the energy which during a given interval passes into heat through tidal action; then, assuming the moon spherical, and her rotation consequently unaltered, we have

$$Q = -\Delta \text{ (energy of earth's rotation)} - \Delta \text{ (energy of lunar orbit)}.$$

By the energy of the lunar orbit is meant the kinetic energy of the revolution of the earth and moon round their common centre of gravity, together with the potential energy of their separation.

Now such energy of orbit $= \text{const} - \frac{1}{2} mm'\mu \cdot \frac{1}{a}$,

where m, m' represent the masses of the two bodies,
μ the attractive force at unit of distance,
a the mean distance;

$$\therefore Q = -\Delta \text{ (energy of earth's rotation)} - \tfrac{1}{2} mm'\mu \frac{\Delta a}{a^2}.$$

Let h denote the angular momentum of revolution,
H the angular momentum of the earth's rotation,

then
$$\Delta H = -\Delta h;$$

but
$$h = \frac{mm'\sqrt{\mu}}{\sqrt{m+m'}} \sqrt{a}\sqrt{1-e^2};$$

$$\therefore \Delta h = \frac{mm'\sqrt{\mu}}{\sqrt{m+m'}} \left\{ \sqrt{1-e^2}\frac{\Delta a}{2\sqrt{a}} - \frac{\sqrt{a}\,.\,e\Delta e}{\sqrt{1-e^2}} \right\}.$$

If S and N denote the components of the reaction of the disturbing forces exercised by the tidal protuberances, estimated tangential and normal (inwards) to the moon's path,

$$\frac{da}{dt} = 2a \cdot \frac{2a-r}{r} \cdot \frac{S}{v},$$

$$ae\frac{de}{dt} = \acute{e}r \sin\phi \cdot \frac{N}{v} + \frac{2a\,(1-e^2)\,(a-r)}{r} \cdot \frac{S}{v},$$

where r is the moon's radius-vector,
ϕ her longitude measured from apogee,
v her velocity in the relative orbit.

As both the coefficients of the disturbing forces in the last expression are small quantities of the order e, it follows that the second term in Δh is negligible with

respect to the first, and we may write

$$\Delta H = -\Delta h = -\frac{mm'\sqrt{\mu}}{\sqrt{m+m'}}\frac{\Delta a}{2\sqrt{a}};$$

$$\therefore Q = -\Delta \text{ (energy of earth's rotation)} + \frac{\sqrt{m+m'}\sqrt{\mu}}{a^{\frac{3}{2}}}\Delta H;$$

or, if I denote the moment of inertia of the earth,
 ω her angular velocity of rotation,
 Ω the mean angular velocity of the moon in her orbit,

$$Q = -I\omega\,\Delta\omega + \Omega\,I\,\Delta\omega$$
$$= -I\omega\,\Delta\omega\left\{1 - \frac{\Omega}{\omega}\right\}.$$

It follows that if ω has the same sign as Ω, not only is all the energy Q turned into heat drawn from the earth's rotation, but, as a necessary concomitant, additional energy is transferred from the earth's rotation to the store of potential and actual energy corresponding to the orbital motion of the system.

It also follows that when Ω is, as in the actual case, very small compared to ω, the energy so transferred bears a very small ratio to Q, and that the energy lost in the earth's rotation is almost the exact equivalent of that consumed in friction.

Let us now consider the case where the plane of the earth's equator does not coincide with the plane of the orbit.

Let G represent the resultant angular momentum of the system which will be fixed in magnitude and direction,
 θ, Θ the angles which the planes of h and H make with the plane of G;

then, since

$$H^2 = G^2 + h^2 - 2G\,.\,h\cos\theta,$$
$$H\Delta H = (h - G\cos\theta)\Delta h + \sin\theta\,.\,G\,h\,\Delta\theta;$$

$$\therefore H\Delta H = \frac{mm'\sqrt{\mu}}{\sqrt{m+m'}}\left\{(h - G\cos\theta)\frac{\Delta a}{2\sqrt{a}} + G\sqrt{a}\sin\theta\,.\,\Delta\theta\right\},$$

or

$$\Delta H = \frac{mm'\sqrt{\mu}\sqrt{a}}{\sqrt{m+m'}}\left\{-\cos(\theta+\Theta)\frac{\Delta a}{2a} + \sin(\theta+\Theta)\,\Delta\theta\right\}.$$

Now if Z denote the component perpendicular to the plane of the orbit of the forces exercised by the protuberances on the moon,
 ψ the angle of elongation of the moon from the ascending node,

$$\frac{d\theta}{dt} = \cos\psi\,.\,\frac{r}{p}\,.\,\frac{Z}{v},$$

where p = perpendicular from earth on tangent to lunar orbit: but

$$\frac{1}{2a}\,.\,\frac{da}{dt} = \frac{2a-r}{r}\,.\,\frac{S}{v};$$

it follows that $\Delta\theta$ and $\frac{1}{2a}\,.\,\Delta a$ in the expression for ΔH bear in general a finite but, in the absence of further information about the position of the protuberances, unknown ratio to each other.

Let the ratio of the first to the second be denoted by λ; then

$$\Delta H = -\frac{mm'\sqrt{\mu}}{\sqrt{m+m'}}\,.\left\{1 - \tan(\Theta+\theta)\,.\,\lambda\right\}\cos(\Theta+\theta)\frac{\Delta a}{2\sqrt{a}};$$

$$\therefore Q = -I\omega\,\Delta\omega\left\{1 - \frac{\Omega}{\omega}\,.\,\frac{\sec(\Theta+\theta)}{1 - \tan(\Theta+\theta)\,.\,\lambda}\right\}.$$

We may therefore still infer that when, as in the actual case, Ω is small compared to ω, the energy lost in the earth's rotation is almost the exact equivalent of that consumed in tidal friction, or in any work done by tidal action. It would also appear that as $\tan(\Theta+\theta)$ is less than $\frac{1}{2}$, and the mean value of λ must be small, the coefficient of $\frac{\Omega}{\omega}$ is positive; and that consequently, as in the case where the equator and the plane of the moon's orbit coincided, so in the actual case there is a small accompanying transfer of energy from the earth's rotation to the orbital motion.

All these conclusions apply *mutatis mutandis* to the solar tides, if we regard as our binary system the earth and sun.

In the case of nature, when we have to consider the three bodies acting together, the main conclusion that nearly all the energy is drawn from the earth's rotation will not be invalidated.

It would also appear that if, as is usually done, we assume the friction to vary as the velocity, the smaller effects (which consist in the transference of energy from the earth's rotation to the energy of the orbit of the moon about the earth and that of the earth about the sun) will correspond to the values separately calculated for the binary systems.

Light.

Further Experiments on Light with Circularly Ruled Plates of Glass. By P. Braham.

On Extraordinary Reflection. By Professor Curtis.

The author drew attention to the fact that in elementary treatises on Experimental Physics no mention is made of extraordinary reflection, whereby students are frequently, although illogically, led to the conclusion that in the case of media which violate the ordinary law of *refraction,* the ordinary law of reflection is fulfilled; while mathematical considerations show that Huyghens's construction is as applicable to reflection as to refraction, and that a ray of light proceeding through a crystal, and impinging on the surface of contact of the crystal with a surrounding medium, will give rise to *two* reflected rays, accompanied by *one* or *two* refracted rays, according as the surrounding medium is ordinary or extraordinary. When the crystal is uniaxial, one of these reflected rays conforms to the ordinary law of reflection, while *in general* the other does not; if the crystal is biaxial, neither of the reflected rays *in general* conforms to that law. If, then, a ray of light falls upon a crystal surrounded by air, part of this light is reflected and part is refracted, the latter being in general split into *two* rays: *each* of these rays will suffer double reflection at the point where it again meets the bounding surface of the crystal; and in the case where the two portions of the bounding surface are parallel, it is an immediate consequence of theory that the planes of polarization of one pair are parallel to those of the other, while the intensities of the light in one pair is not in general the same as in the other, and in fact one or more may vanish without the others vanishing.

These facts were illustrated by an apparatus consisting of a horizontal stage free to move round and along a vertical axis; on this stage a uniaxial or biaxial crystal is placed, and a ray of light is allowed to fall on it through a tube properly adjusted and fitted by a cap, in which is a small orifice: at the opposite side of the stage is placed another tube properly adjusted; on looking through it, *five* images of the small orifice in the cap of the first-mentioned tube are seen—one formed by reflection at the upper surface of the crystal, and the other *four* by the *double* reflection of the two rays refracted at the upper surface. As the stage is rotated the images may be four, three, or two; if the cap in the first tube be replaced by a Nicol's prism, the images as the stage is rotated may be four, three, two, or one. The

planes of polarization of the rays proceeding from the four images may be determined by introducing a Nicol's prism into the tube, to which the eye is applied.

On the Construction of large Nicol's Prisms.* *By* W. Ladd, *F.R.A.S.*

On the Construction of a perfectly Achromatic Telescope†.
By Professor G. G. Stokes, *M.A., Sec. R.S.*

At the Meeting of the Association at Edinburgh in 1871, it was stated that it was in contemplation actually to construct a telescope, by means of disks of glass prepared by the late Mr. Vernon Harcourt, which should be achromatic as to secondary as well as primary dispersion. This intention was subsequently carried out, and the telescope, which was constructed by Mr. Howard Grubb, was now exhibited to the Section. The original intention was to construct the objective of a phosphatic glass containing a suitable percentage of titanic acid, achromatized by a glass of terborate of lead‡. As the curvature of the convex lens would be rather severe if the whole convex power were thrown into a single lens, it was intended to use two lenses of this glass, one in front and one behind, with the concave terborate of lead placed between them. It was found that, provided not more than about $\frac{1}{3}$ of the convex power were thrown behind, the adjacent surfaces might be made to fit, consistently with the condition of destroying the spherical as well as the chromatic aberration. This would render it possible to cement the glasses, and thereby protect the terborate, which was rather liable to tarnish.

At the time of Mr. Harcourt's death, two disks of the titanic glass had been prepared, which it was hoped would be good enough for employment, as also two disks of terborate. These were placed in Mr. Grubb's hands. On polishing, one of the titanic disks was found to be too badly striated to be employed; the other was pretty fair. As it would have required a rather severe curvature of the first surface, and an unusual convexity of the last, to throw the whole convex power into the first lens, using a mere shell of crown glass behind to protect the terborate, Prof. Stokes thought it more prudent to throw about $\frac{1}{6}$ of the whole convex power into the third or crown-glass lens, though at the sacrifice of an *absolute* destruction of secondary dispersion, which by this change from the original design might be expected to be just barely perceptible. Of the terborate disks, the less striated happened to be *slightly* muddy, from some accident in the preparation; but as this signified less than the striæ, Mr. Grubb deemed it better to employ this disk.

The telescope exhibited to the Meeting was of about $2\frac{1}{2}$ inches aperture and 28 inches focal length, and was provided with an objective of the ordinary kind, by which the other could be replaced, for contrasting the performance. When the telescope was turned on to a chimney seen against the sky or other suitable object, and half the object-glass covered by a screen with its edge parallel to the edges of the object, in the case of the ordinary objective vivid green and purple were seen about the two edges, whereas with the Harcourt objective there was barely any perceptible colour. It was not, of course, to be expected that the performance of the telescope should be good, on account of the difficulty of preparing glass free from striæ, but it was quite sufficient to show the possibility of destroying the secondary colour, which was the object of the construction.

On a Form of Spottiswoode's Triple Combination of Double-Image Prisms and Quartz Plates applied to the Table Polariscope. *By* S. C. Tisley.

This instrument consists of an eyepiece substituted for the usual Nicol prism analyzer of the ordinary table polariscope. It contains five cells capable of being

* Published in 'Nature,' vol. x. p. 451 (Oct. 1, 1874). † *Ibid.* p. 431 (Sept. 24, 1874).

‡ The percentage of titanic acid was so chosen that there should be no irrationality of dispersion between the titanic glass and the terborate.

brought into the line of vision singly or in combination, and of being rotated separately or as a whole. On the stage of the instrument a quartz plate is placed with a diaphragm, giving the original beam of polarized light. By means of the first double-image prism this beam is divided into two, showing the component parts of which the tint is composed. A second prism can be now applied; this will divide each beam into two parts, making four images, and the third double-image prism will give eight images; so that the original beam can be split up into eight component parts. The two quartz plates can then be introduced between the prisms, giving additional power in the analysis of colours.

This instrument also has a small arm for carrying a pocket-spectroscope, which can be brought into the line of vision over the ordinary analyzer to enable the operator to analyze the colours by means of the spectroscope.

On a New and Simple Form of adjustable Slit for the Spectroscope. *By* S. C. Tisley.

The end of the spectroscope-tube is screwed on the outside so that the cap on being turned round is gradually drawn down; this being bevelled on the inside, the bevel acts upon the ends of the jaws of the slit, which are correspondingly bevelled, and so closes the slit, a spring wire being used to open the slit when the cap is unscrewed.

Advantage is taken of the cap, and a glass cover is inserted so as to keep the slit free from dust, the usual pull-off cap or case being entirely dispensed with; every part of the instrument is easily accessible, and at the same time is solid and compact.

By this means a really practical pocket-spectroscope can be constructed, and no loose cap or cover is required to protect it when out of use; it is always ready at a moment's notice, and the utmost precision is obtained in the adjustment of the slit without any very delicate screws being employed.

Electricity and Magnetism.

On some Peculiarities in the Electric Discharge from a Leyden Jar. *By* Dr. W. Feddersen, *Leipzig.*

The author showed a number of photographs obtained by projecting an image of the discharge-spark of a Leyden battery on to a sensitive plate by means of a rotating concave mirror, and illustrated by reference to them the nature of the movement of electricity which must be conceived of as occurring when such discharges take place under varying circumstances.

When the Leyden jar is discharged through a circuit of small resistance, the way in which the discharge takes place is that the opposite electricities of the two coatings do not neutralize each other at once, but as it were pass through each other several times in succession in a continually smaller and smaller quantity, so that at definite successive instants the jar appears to be charged alternately positively and negatively, but each time less and less strongly. This is the *oscillatory* discharge, which reveals itself in the photographs by maxima of illumination following each other at equal distances. The known rate of rotation of the mirror gives the duration of the oscillation. Experiments show that this duration is proportional to the square root of the number of jars* (capacity of the battery) employed, that it depends on the form of the discharging circuit, and increases with the length of the circuit and decreases with its thickness in a complex ratio†, but is nevertheless independent of the resistance of the conductor. On the other hand, however, the *number* of oscillations seems to be essentially affected by this resistance; when the resistance increases, the number becomes smaller, and, with a certain very high resistance (which the author calls the "limiting resistance"), the oscillatory character of the discharge ceases‡. When this resistance has been reached, we

* Poggendorff's 'Annalen der Physik u. Chem.' cxvi. 153. † *Ibid.* cxvi. 164–169.
‡ Represented in reverse order in Pogg. 'Annalen,' cxvi. pl. i. figs. 25–28.

have at first a simple flowing off of the electricity, occupying about the period of one oscillation; but, when the resistance becomes greater still, the discharge occupies a longer time. This is the *continuous* discharge. The limiting resistance in its turn follows special laws*; it is inversely proportional to the number of jars (capacity), and increases slowly with the length of the discharging circuit (potential of the current).

The correctness of the author's interpretation of the electrical photographs, and of similar experiments since made by others, as well as of the conclusions deduced from it—that in almost all cases when a Leyden jar is discharged through a metallic conductor an oscillatory discharge takes place, and that the usual mode of representing the motion of electricity during the discharge (which we meet with, for instance, in Riess's 'Die Lehre von der Reibungselectricität') is incorrect—follows,

1st. From the agreement with theory. Sir William Thomson† and Professor Kirchhoff‡ had previously shown, by theoretical considerations, that under some circumstances an electric discharge must exhibit such oscillations. Subsequently Kirchhoff submitted the author's observations to a numerical calculation§, and, disregarding a constant factor, found them to agree completely. Moreover the author has himself examined ‖ theoretically the laws of the strength of the currents in divided circuits in the case of an oscillating discharge, and has discovered their agreement with certain remarkable observations by Knochenhauer¶ on the electrical air-thermometer, as well as their relation to his observations of oscillation.

2nd. From an experimental point of view, the interpretation that has been given is supported by a variety of other investigations. Without reckoning the experiments of Priestley, Savary, Riess, and others, which were made some of them a long time ago and only doubtfully indicate this explanation, the following experimental results may be mentioned:—the proof given by Paalzow** that in some discharges there is a current in two opposite directions; the negative residual charge obtained by Von Oettinger†† (though not under ordinary conditions) with a positively charged Leyden jar; and, lastly, the sixteenfold increase of the deflection of a galvanometer observed by the author‡‡ when the oscillatory discharge was sent through its coils interposed between a Gaugain's double electrical valve. Time did not allow of mentioning other experiments and observations of the author which bear on the same point, and are to be found in various places in Poggendorff's 'Annalen.'

The question has been raised whether the photographically represented oscillations might not coincide with the discontinuous discharge observed by Wiedemann and Ruhlmann§§. The author contradicts this suggestion, and adds that he had observed ‖‖ similar partial discharges before he discovered the oscillations of the discharge of a Leyden jar. The discontinuous discharge, however, only occurs with the highest resistances, such as those offered by capillary columns of distilled water, and when the discharging circuit is well insulated; and successive partial discharges differ from the oscillations in following each other at continually greater and greater intervals instead of at a constant distance.

Geometrical Illustrations of Ohm's Law. By Professor G. C. Foster, *F.R.S.*

The object of this paper is to point out an easy method of deducing the permanent resistance and electromotive force of a galvanic circuit from two observations with a tangent- or sine-galvanometer, without using trigonometrical tables.

I. *Observations with a tangent-galvanometer.*—A battery, connected in simple

* Pogg. 'Annalen,' cxii. 452 *et seq.*

† Phil. Mag. [4], v. 393 *et seq.*

‡ Pogg. 'Annalen,' c. 193.

§ Pogg. 'Annalen,' cxxi. 551 *et seq.*

‖ *Ibid.* cxxx. 439 *et seq.*

¶ The observations referred to are to be found scattered through Knochenhauer's various papers, published for the most part in Poggendorff's 'Annalen.'

** Paalzow allowed the discharge-current to pass through a Geissler's tube above the poles of a powerful electromagnet (Pogg. Annalen, cxii. 572).

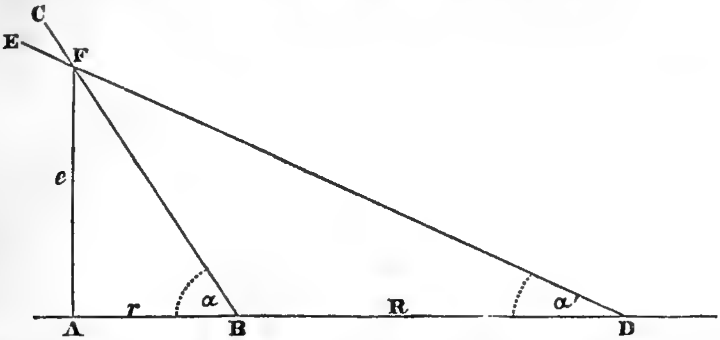
†† Pogg. 'Annalen,' cxv. 513 *et seq.*

‡‡ *Ibid.* cxv. 336 *et seq.*

§§ *Ibid.* cxlv. 235 *et seq.*

‖‖ *Ibid.* ciii. 69 *et seq.*

circuit with a tangent-galvanometer and set of resistance-coils, causes the galvanometer-needle to be deflected from the magnetic meridian through an angle α; on adding to the circuit an additional resistance R, the deflection of the needle diminishes to the value α'. From these observations it is required to deduce the original resistance r and the electromotive force e of the circuit.



From any point B in the straight line AB draw BC, so that angle ABC$=\alpha$; take BD, in AB produced, to represent the added resistance R, and draw DE so that angle ADE$=\alpha'$. Since the angle at B ($=\alpha$) is greater than the angle at D ($=\alpha'$), the straight lines BC and DE must intersect (both being drawn on the same side of AB). Let F be the point of intersection, and draw FA perpendicular to AB: then the distance AB, between the point B and the foot of the perpendicular from F, will represent the original resistance of the circuit r, on the same scale as that on which BD represents the added resistance R; and the perpendicular AF will represent the electromotive force e, in terms of that electromotive force taken as unity which, if it acted in a circuit of unit resistance, would produce a current capable of causing a deflection of 45° on the galvanometer employed.

If the strength of the current in the first experiment be denoted by c, and in the second experiment by c', we have, by experiment,

$$c=\tan\alpha=\frac{\text{AF}}{\text{AB}}, \text{ and } c'=\tan\alpha'=\frac{\text{AF}}{\text{AD}}=\frac{\text{AF}}{\text{AB}+\text{BD}};$$

also, by Ohm's law,

$$c=\frac{e}{r}, \text{ and } c'=\frac{e}{r+\text{R}}.$$

Therefore

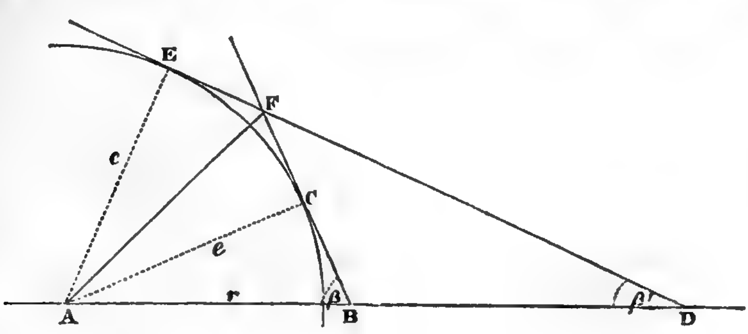
$$\frac{r}{e}=\frac{\text{AB}}{\text{AF}}, \text{ and } \frac{r+\text{R}}{e}=\frac{\text{AB}+\text{BD}}{\text{AF}};$$

whence

$$\frac{r}{\text{AB}}=\frac{e}{\text{AF}}=\frac{\text{R}}{\text{BD}},$$

which proves the construction.

II. *Observations with a sine-galvanometer.*—In this case let the first angle of deflection be denoted by β, and that obtained after adding to the circuit a resistance



R by β'. As before, in the straight line ABD take BD to represent the added resistance R, and draw BC and DE so that the angles ABC and ADE are respectively equal to β and β'; and let BC and DE intersect in F. Draw FA to bisect the external angle EFB; and let A be the point where the bisector of this angle cuts the original straight line ABD. Then the permanent resistance will be represented by AB, and the electromotive force by the radius of the circle drawn about the centre A so as to touch the straight lines BC and DE, the unit electromotive force being that which, in a circuit of unit resistance, would give a current capable of deflecting the sine-galvanometer employed through an angle of 90°.

The experiments give

$$c = \sin\beta = \frac{AC}{AB}, \text{ and } c' = \sin\beta' = \frac{AE}{AD} = \frac{AE}{AB+BD},$$

AC and AE being both of them radii of the circle drawn about the centre A. Consequently

$$\frac{r}{e} = \frac{AB}{AC}, \text{ and } \frac{r+R}{e} = \frac{AB+BD}{AE};$$

whence

$$\frac{r}{AB} = \frac{e}{AC \text{ or } AE} = \frac{R}{BD},$$

which proves the construction.

It is evident that, with a perfectly constant battery, if a series of experiments are made by giving various values to the resistance R, all the lines drawn in the same way as BC and DE will pass through the *same point* in the case of a tangent-galvanometer, and will all be tangents to the *same circle* in the case of a sine-galvanometer.

Suggestions for a Redetermination of the Absolute Electromagnetic Units of Resistance and of Electromotive Force. *By* Prof. G. C. Foster, *F.R.S.*

On Ohm's Law. *By* Arthur Schuster, *Ph.D.*

Ohm's law has often been subjected to an experimental verification. None of the methods employed, however, were sufficiently delicate to prove the law between very wide limits. The author thinks that the following method will allow us to judge with far greater certainty whether Ohm's law is rigidly true. If we send rapidly alternating currents through a galvanometer they will not affect the position of the needle, as the two currents going in opposite directions will balance each other, if the circuit is in its normal state (see paper on unilateral conductivity, p. 31). If we send in rapid succession two currents through the galvanometer which have different intensities, they will have the same effect as one current, the intensity of which is the arithmetic mean between the two currents. Let the electromotive force of one of the currents be $E+x$, of the other $E-x$; then, if the resistance is the same in both cases, the two currents will have the same effect as a single current produced by an electromotive force E. On the other hand, if this is not the case, the resistance for the electromotive force $E+x$ must be different from the resistance for the electromotive force $E-x$.

A weak constant current is sent through a galvanometer and a coil in which a magnet was rotated. The currents induced by the rotating magnet had no effect on the galvanometer-needle when the constant current did not pass. When the current passed, however, the rotating magnet always increased the deflection. In order to explain this result we are obliged to make one of the two following suppositions:—

1. The resistance of the wire decreases as the current increases.
2. The self-induction of a wire involves a term depending upon the strength of a current and approaching a limiting value as the current increases.

On Unilateral Conductivity. *By* Arthur Schuster, *Ph.D.*

While engaged in other work the author discovered a new phenomenon in electricity which may conveniently be called unilateral conductivity. His experiments show that in a circuit composed entirely of copper wires, joined together by means of binding-screws, the electric conductivity in one direction may be different from what it is in the opposite direction. If a coil of wires be connected with the galvanometer, and a magnet rotates rapidly within, the coil-currents in alternate direction will pass through the galvanometer. Their effect, however, on the needle will counteract each other, and the needle will show no permanent deflection if the currents are equally strong. On the other hand, if the needle shows a permanent deflection, one current must be stronger than the other; and this again can only be caused by a difference in the conductivity, as the electromotive force acting in opposite directions must be equal. It is found that sometimes the currents induced by the rotating magnet have a very strong effect on the needle, and the effect shows best in wires which have not been used for a certain time. The most remarkable fact connected with unilateral conductivity is, that a circuit of wires not showing unilateral conductivity may be made to conduct unilaterally by merely introducing for a short time a wire which shows the effect. When the wire is taken out, the original circuit will again show unilateral conductivity. The air condensed on the surface of the wire may possibly cause the phenomenon. Two wires screwed together may not touch each other, but a small layer of air may separate them. A voltaic arc, the two electrodes of which are of different form, will, as is known, show what is called unilateral conductivity, and a copper wire separated from the binding-screw by a thin layer of air will act somewhat like a voltaic arc. In order to test the theory according to which the facts mentioned above are easily explained, air was artificially condensed on the wire by having its ends put for a certain time into powdered charcoal. A wire which showed no unilateral conductivity was thus made to show it; and after it had been destroyed again, which generally can be done by rubbing the wire or screwing it to another binding-screw, unilateral conductivity was produced a second time by the same means. A third attempt, however, failed, and from that time all the means by which usually unilateral conductivity had been produced were not successful. If, therefore, the above theory is the correct explanation of unilateral conductivity, some unknown secondary cause (perhaps the diffusion of the gas into the wire) must be active, which at certain times prevents it being produced.

A New Method of constructing Carbon-cells and Plates for Galvanic Batteries. *By* W. Symons, *F.C.S.*

The author mixes finely powdered wood-charcoal with a syrup of white sugar to a proper consistence. In this thick syrup he dips paper moulds, only covering the outside. After drying he redips, and repeats until sufficiently thick. When well dried, the cells are packed in sand and baked in an oven sufficiently hot to burn out the paper moulds. Then soaked in weak hydrochloric acid, dried, soaked in sugar-syrup, then buried in sand and gradually brought up to a white heat. The carbon has a good metallic ring and a brilliant fracture. The outside of the cells can be covered with paper and dipped in melted paraffin. Rods and plates of carbon can be easily rolled out or pressed if made of a similar mixture, but thicker.

Notes on a New Method for the Electrochemical Decomposition of Oils and other Non-conducting Liquids.* *By* W. Symons, *F.C.S.*

The author described a method for subjecting various oils, carbon disulphide, and other non-conducting liquids to the action of a weak but continuous galvanic current, by dissolving them either in a solution of zinc chloride in alcohol or of ferric chloride in ether. The latter he finds the best medium; and oils &c. dissolved in it may be subjected to the galvanic current for some days, various products of decomposition

* The paper is printed in full in the 'Pharmaceutical Journal' for October 1874.

being the result. Carbon disulphide may also be added to the oils, or acted on alone. Other conducting liquids, not miscible with ether, may also be used as anodes or cathodes.

Oils, however, which are not soluble in alcohol are only partially soluble in the ferric ether, which fact also suggests matter for future experiments. The author considers it a significant fact that in some of these experiments carbon disulphide was evidently decomposed, either directly or indirectly, by the current, although he has not yet succeeded in getting a deposit of carbon.

A cheap and convenient Galvanic Battery adapted for weak but continuous Currents. By W. Symons, *F.C.S.*

This home-made battery, adapted either for a water-battery or for a weak saline solution, was used in the previous experiments, and is also described in the 'Pharmaceutical Journal' for October 1874.

On the Effect on the Compass of the Rolling of Ships. By* Sir W. Thomson, *F.R.S.*

On the Proportions in which Bases and Acids present in a Solution combine with each other. By Professor Gustav Wiedemann, *Leipzig University.*

When a base is introduced into a solution containing two different acids, it is divided between them; likewise, when salts are dissolved in water, they very often undergo a partial decomposition. Thus, for example, the salts of iron peroxide dissolved in water are partially decomposed into acid, and colloid peroxide of iron remaining in solution.

The author has applied to the investigation of this phenomenon a method previously employed by him for the determination of the magnetism of chemical compounds. In this process the effect which is to be determined is not measured during the continuance of the chemical action, as is customary in measuring calorific effects, but after the complete termination of the action, and without the intervention of any external agent, physical or chemical.

This method has as its basis the difference which exists between the magnetism of the colloidal peroxide of iron and that of the peroxide contained in the salts. When in a solution of a neutral or feebly acid salt of peroxide of iron a portion of the salt is decomposed into free acid and colloid peroxide in solution, the modification which the magnetism undergoes should enable us to calculate the quantity of salt decomposed.

If we designate by m_0 the magnetism in a unit of weight of iron in its ferric salts in a solid state or dissolved in an excess of acid, by m_1 the magnetism of a unit of weight of iron contained in the colloid peroxide in solution, by m the magnetism of the unit of weight of iron in any solution whatever of a salt of iron peroxide which has undergone a partial decomposition, and, finally, by $1-x : x$ the ratio of the quantity of the peroxide remaining combined in the form of salt to the quantity of the peroxide that has assumed the colloid state, we have

$$m=m_0(1-x)+m_1x,$$

and consequently

$$x=\frac{m_0-m}{m_0-m_1}.$$

The ratio $1 : x$ is thus immediately deduced from the measure of the magnetism of the solution. In this way the following results have been obtained:—

1. The magnetism of a solution of ferric sulphate does not undergo any sensible change, even when so diluted as to reduce the quantity of iron contained in 10 cubic centims. of the solution from 0·57 gramme to 0·07 gramme.

* Published in 'Nature,' vol. x. p. 338 (Sept. 10, 1874).

2. If to a solution of colloid peroxide of iron containing a small quantity of sulphuric acid we add constantly increasing quantities of (diluted) sulphuric acid, the quantity of ferric sulphate contained in the solution also gradually increases, while a portion of the colloid peroxide and a portion of the acid remain side by side uncombined.

3. If the quantity of sulphuric acid is less than that which corresponds to an equivalent of the peroxide, the formation of the ferric sulphate takes place at first more rapidly than normally should be the case, considering the increase of the acid; consequently it tends gradually to a maximum.

Even when in this case the quantities of sulphuric acid and peroxide of iron are in the ratio of their equivalents, not more than 75 per cent. of those two substances enter into combination, 25 per cent. of the oxide and the acid remaining free in the solution.

By taking larger and larger quantities of the acid (2 or 2·5 equivalents) for one equivalent of the peroxide, the quantity of free peroxide is gradually diminished (to 10 or 4 per cent.).

4. It follows from these results that, on taking increasing quantities of sulphuric acid for an equivalent of the peroxide, we observe at first that the quantity of free acid in the solution diminishes; and this phenomenon continues until the total quantity of acid, free as well as combined, is a little more than one equivalent. As we continue to add acid to the solution, the proportion of free acid increases still further.

5. We obtain, moreover, the remarkable result that the quantity of peroxide of iron, combined with a constant quantity (one equivalent) of acid in these solutions, attains its maximum when the proportion of acid exceeds by a small quantity the oxide of iron, equivalent for equivalent.

6. The solutions of iron-ammonia alum give numerical results, which are almost identical with those obtained with a solution of one equivalent of peroxide of iron and one equivalent of sulphuric acid. The ammonia-salt contained in the alum exercises in this case no sensible influence upon the decomposition which results in the aqueous solution; so that we are justified in concluding that the iron alum in solution is entirely decomposed into sulphate of ammonia and ferric sulphate, the latter of which undergoes partial decomposition.

7. By measuring the magnetism of a solution of peroxide of iron containing two different acids or of a solution of an acid containing peroxide of iron and another base (alumina), we may determine in the same way the division of the peroxide of iron between the two acids, or of the acids between the two bases.

8. It would be difficult to give a mathematically exact theory of the facts just presented, for a great number of different factors come into play. We can, however, henceforward regard as inaccurate all those formulæ which give the quantities of base remaining free in a solution containing an acid as a function of the second degree of the quantity of the acid.

For further details the reader is referred to the complete memoir, published in the 'Berichte der königl. sächsischen Gesellschaft der Wissenschaften, Math.-phys. Classe.'

Notes of Experiments on the Electric Currents produced by the Gramme Magneto-electric Machine. By Alf. Niaudet Breguet, *of Paris.*

Two Gramme machines (called, for distinction, A and B) are placed in the same circuit. On turning the first, A, an electric current is produced which traverses the second, B, and the latter begins to turn.

It therefore appears that the Gramme machine is equally fitted to convert force into electricity and electricity into force. In fact all electric and electromagnetic machines have that property, but none have hitherto possessed this reversibility in the same degree.

This experiment proves that a system of two Gramme machines might be applied to the transmission of force to a considerable distance, the immovable conductors replacing the means of transmission or teledynamic cables of Mons. Hirn. An analogous combination would permit the distribution of the force applied to a large

Gramme machine through a certain number of smaller machines, placed at points more or less distant.

Experiments now in progress will, it is hoped, prove to the British Association at its next Meeting how far these ideas are practicable and may be useful; these experiments will, to use the language of the mechanical theory of heat, show the economic coefficient of the system in question.

The first experiment may be slightly modified as follows:—

In the circuit of the two Gramme machines insert a platinum wire; stop machine B and turn machine A: the platinum wire heats, and indeed becomes red-hot by the passage of the current from A; machine B remains quiescent, having been stopped; but if the stoppage be removed it will be seen to move immediately, and, immediately also, the platinum wire ceases to be red.

The second experiment presents, I think, a sufficiently striking example of the equality of mechanical action and heat; besides which it realizes in a new manner an experiment described by Helmholtz in his paper on the "Conservation of Force." Helmholtz operated with a pile which turned an electromagnetic machine; a galvanometer was placed in the circuit, and its deviation was seen to diminish in proportion as the rapidity of the machine increased; he showed that the deviation of the galvanometer would be *nil* at a certain rapidity of the machine. We shall show that in our experiment, the two machines being supposed to be alike, the deviation of the galvanometer and the intensity of the current would become *nil* when the rapidity of the two machines is the same.

Finally, our second experiment may also be looked at from another point of view; it affords an illustration of Neumann's principle, which may be described in the following words:—"Every effect produced by an electric current involves a diminution of the intensity of such current."

We observe, in conclusion, that so extensive and general a principle cannot be proved by experiment, any more than the principle of action being equal to reaction; with truths of this nature we can but claim to accumulate demonstrative verifications, and it is without doubt interesting to search for such as may strike the mind of the student.

[M. Breguet's instruments referred to in this abstract were exhibited to the Members of the Association on Tuesday, August 25, after the Sections were closed. The paper was not read at the Meeting, but the abstract is printed with the authority of the Council.—G. G.]

METEOROLOGY.

On the Cause of the Progressive Motion of Cyclones, and of the Seasonal Variations in their Paths. By ISAAC ASHE, *A.B., M.B., T.C.D.*

Dr. Ashe pointed out the importance of arriving at a correct theory regarding the causes of the onward progress of cyclones over the face of the globe, on account of the light which would thereby be thrown on the question of seasonal variations in their paths, such as had been observed by Captain Fyers, R.E., in the South-Indian Ocean. A correct theory would serve to indicate the line of research in future observations directed towards this point. Seasonal variations of path would be due to special modifications of the more constant forces governing the paths and progress of cyclones, such special modifications being dependent on the changes induced in the action of the forces causing such progress in consequence of changes of season. The general law would depend on the more constant, and the seasonal variation on the less constant elements of these forces. The more constant elements would be those inherent in the cyclone itself; the less constant elements would be those depending on the prevailing winds of the zone and their seasonal variations. The varying elements were better known than the fixed, though perhaps their causal relation was not recognized from want of acquaintance with the fixed elements and more constant forces inherent in the cyclone itself, on which the onward progress of the cyclone depended.

Dr. Ashe reviewed the known laws of cyclonal progress, their motion towards the S.W. in the southern, and the N.W. in the northern hemisphere while within the tropics, and remarked that in both cases this direction was nearly at right angles to the trade-wind of the hemisphere, and could not therefore be a motion due to the trade-wind. He noticed their recurving at the tropics, and subsequent course to S.E. in the southern and to N.E. in the northern hemisphere, and pointed out that since this occurred in the open sea as well as near land, it must depend on the latitude and some causal change connected therewith, and not on the proximity of land as some had supposed. He adduced Captain Fyers's observations (Trans. Met. Soc. Mauritius, vol. iii. p. 29) as to the onward progress of cyclones being very slow at first on their formation near the equator, and increasing in rapidity afterwards, apparently *pari passu* with their poleward motion. The author then pointed out that, in consequence of the difference in the rate of the earth's diurnal rotation at different latitudes, air drawn into a cyclone from equatorwards would be moving more rapidly than the centre of the cyclone, and hence as it revolved round the centre in the eastern half would be discharging force into the mass of moving air, and thus accelerating its speed of revolution; while air drawn in from polewards, since it would be moving more slowly than the centre, would similarly use up the force of the western half, and so retard its speed of revolution. The same causes would also make the cyclone assume an elliptical, rather than a strictly circular figure, as usually supposed; and the western half would present a greater excentricity, on account of the greater differences of length in the degrees of longitude for equal intervals of latitude as we approach the pole; air from polewards would pass more to westward than air from equatorwards would to eastward; hence the western half would have the larger surface, and would therefore experience more friction against the surface of the ocean than would the eastern. Both these effects would tend to produce the same result, namely, the comparatively slower revolution of the western half, a slower motion of the air composing it; this would cause the eastern half to roll over or past the western, and so produce a general onward progress of the cyclone in a direction parallel to a tangent to the extreme western point of the storm; that would, in fact, be along the minor axis of the ellipse, since such the author regarded it, formed by the storm, or, in short, in a poleward direction in both hemispheres. Some persons had supposed that the air in the western half of a cyclone would move the fastest because it moved along with the trade-wind, while that in the eastern half moved against it; but the author pointed out that this could only affect the rate of motion relatively to a ship at sea, and not as regarded the internal constitution of the cyclone. We should investigate the proper motion of the cyclone independently, and afterwards consider the entire cyclone as being carried on along with the trade-wind within which it was generated. The proper motion, then, the author considered to be to polewards in both hemispheres, or due south in the southern, and due north in the northern, though some easting might occasionally be due to a rapid poleward progress of the whole storm. To this proper motion the trade-wind component should now be added, or a N.W. progress in the southern hemisphere and a S.W. in the northern. The resultant of these two, supposing them about equal in force, would give the actual intratropical path of the storm in each hemisphere, or W.N.W. in the northern and W.S.W. in the southern. This was in exact agreement with the observed paths. At the tropics, the trade-wind failing, the proper poleward motion would alone remain; this also was in agreement with observation. Beyond the tropics the storm would come under the influence of the S.W. and N.W. counter-trades, and the resultant would be a N.N.E. path in the northern hemisphere and a S.S.E. in the southern; this also corresponded exactly with the results of observation. As the trade-winds increased in strength in the summer of each hemisphere the component of force due to their action would be greater, and a storm in the northern hemisphere would take a more southerly course, and in the southern hemisphere a more northerly course than at other seasons. This also was in accurate agreement with Captain Fyers's observations of the storms of the South-Indian Ocean, since he finds (Trans. Met. Soc. Maur. vol. iii. p. 13) that "the November and December storms take a more southerly course than those of the succeeding months, January, February, and March." After April the hurricane season as a rule is over in the South-Indian

Ocean, which the author accounted for by supposing that the trade-wind component of the cyclone's motion is then sufficiently strong to draw any cyclone that may be formed into the equatorial calm-belt during its period of slow proper motion on its first formation near the equator, where the degrees of longitude differ but little in length at different latitudes. Captain Fyers had observed this slow progress on the first formation of a storm, and the cyclone would in consequence be soon lost in the ascensive motion of the air within the equatorial calm-belt.

On Disturbance of the Weather by Artificial Influences, especially Battles, Military Manœuvres, great Explosions, and Conflagrations. By R. B. Belcher.

Many instances were quoted, from the siege of Valenciennes in 1793 to the Ashantee and Carlist wars this year, to show that storms follow immediately upon battles. The loss of the great battle of Solferino, which closed the Italian campaign of 1859, was attributed by the Austrian commander to a terrific thunder-storm which burst over the field and obscured movements of powerful masses of the enemy. The decisive battle of Sadowa, which closed the Austro-Prussian war in 1866, was in like manner accompanied by a terrible storm, to which again the Austrian commander attributed his defeat.

The sham-fights at and near Aldershot this year, viz. May 19, June 19, 20, July 8, 20, 21, 27, 29, were in each instance followed by thunder-storms, lasting several days, with fine weather in the intervals.

The manœuvres at Dartmoor and Cannock, August 1873, brought such stormy weather, that the former was broken up prematurely, and the latter carried on with difficulty. Correspondents at Cannock Chase describe the artillery below as setting in motion the artillery above and bringing down the rain in torrents.

Instances of great explosions being immediately followed by thunder-storms were given, notably one in the harbour of Bordeaux, September 1869, which was followed by a cyclone accompanied by an enormous wave which swept the shores of France and England; it was succeeded by a remarkable lightning-storm.

Instances of large conflagrations which appeared to cause storms were given.

On certain protracted Irregularities of Atmospheric Pressure in the Indian Monsoon Region, and their relation to Variations of the Local Rainfall. By Henry F. Blanford, *F.G.S.*

After briefly noticing the distribution of atmospheric pressure which in Northern India normally accompanies the two monsoons, and which has been described at length elsewhere, the author draws attention to a fact disclosed by a discussion of the barometric registers for the last seven years, viz. that the abnormal peculiarities of relative pressure distribution which may appear in any season, tend to last for many months, and in some cases apparently throughout several alternations of the monsoons. In the year 1868 a remarkable and unusually intense barometric depression in the N.W. corner of the bay of Bengal characterized the whole of the S.W. monsoon, while in Lower Bengal the pressure was for the most part above the average. In 1871 a similar but less intense barometric depression existed in the east of the bay, and another in Orissa; also in Central India, north of the Satpoora range, the pressure was unusually below that of the Gangetic plain on the north and that of Nagpore on the south of the range. In 1872 the last depression had disappeared, and that of Orissa and that in the east of the bay were united into one, the depression being greatest in that part of the bay off the coast of Orissa. In 1873 this last depression continued, while another existed in the neighbourhood of the Nicobar Islands, and a third in the province of Oudh, which was very intense during the S.W. monsoon. The author concluded, from the facts adduced, "that amid the never-ceasing changes of condition and place to which every part of the atmosphere is subject, certain states tend to perpetuate or reproduce themselves in the same region, in such manner as to maintain a constant difference in the mean or average

pressures of two neighbouring regions; and that this tendency to a constant local difference is, in certain cases, maintained throughout those great revolutions of atmospheric density, composition, and movement which accompany the alternations of the monsoons. Nevertheless these states, though protracted, are not permanent, and disappear after a longer or shorter time, sometimes suddenly, but more frequently by a graduated decrease."

The author then proceeded to notice certain relations between these barometric irregularities and the distribution of the rainfall in these years. In 1868, more especially in the months of June and August, when the pressure was at its lowest in the N.W. corner of the bay of Bengal, there was an excessive fall of rain in the S.W. corner of the Gangetic delta—the greatest fall in each of these months being about 100 miles to the north of the place of greatest depression, thus showing a certain analogy to the case of cyclones, in which the heaviest rainfall is in advance of the centre of the storm. The year 1871 was one of unusually heavy rainfall in Bengal, the N.W. Provinces, and Central India, indicating a somewhat similar relation to the areas of abnormal barometric depression of that year. In 1873, again, which was one of very deficient rainfall in most parts of Northern India, the Punjab (which lay beyond the Oudh depression) and Burmah (which lay beyond that of the Nicobars in the direction of the monsoon currents) enjoyed a plentiful rain supply. But the deficient rainfall of that and the preceding year in Bengal cannot be thus explained; and although it can hardly be doubted that the abnormal peculiarities in the distribution of pressure must be very influential in determining those of the rainfall, the author thinks that no satisfactory discussion of their relations is possible without a knowledge of the state of atmospheric pressure over the whole region concerned with the Indian branches of the monsoons.

On the apparent Connexion between Sun-spots and Atmospheric Ozone. By T. MOFFAT.

The author stated that he had compared the mean daily quantity of ozone for each year for nineteen years with the number of new groups of sun-spots which appeared in each year, and the results showed that the maximum of sun-spots occurred in the same year as the maximum of ozone, and the period of minimum of sun-spots coincided with that of the minimum of ozone.

On a Gymbal-swung Rain-gauge. By F. PASTORELLI.

The author submitted for criticism a gymbal-swung rain-gauge provided below the gymbals with a spherical receptacle of so much larger area than the funnel, that the pressure of the wind upon it should tilt the funnel towards the point whence the rain is falling. He also suggested that by duly weighting it might answer on board ship.

On the Importance of Improved Methods of Registration of Wind on the Coast, with a notice of an Anemometer designed by Mr. W. De La Rue, *F.R.S., to furnish Telegraphic Information of the Occurrence of Strong Winds. By* ROBERT H. SCOTT, *M.A., F.R.S.*

It is hardly necessary to draw the attention of men of science to the fact, that the configuration of the earth's surface exercises an overwhelming influence on the wind both as to its direction and force. Some statements and tables contained in a paper by the author in the last Number of the 'Quarterly Journal of the Meteorological Society'* abundantly prove this assertion, and it is therefore easy to see what an imperfect representation of the actual force of the wind at sea can be furnished by reports from a broken and mountainous coast, such as the Atlantic coasts of Ireland

* "An attempt to establish a relation between the Velocity of the Wind and its Force (Beaufort scale), with some Remarks on Anemometrical Observations in General," by Robert H. Scott, F.R.S., Quart. Journ. Meteor. Soc. vol. ii. p. 109.

and Scotland, where the telegraphic stations are, perforce, situated in sheltered places, inasmuch as harbours are naturally found where there is as little exposure to wind as is possible.

In the practice of weather-telegraphy and storm-warnings, as the number of reports received per day from each station is strictly limited, on financial considerations, it is quite obvious that if the actual epoch of the commencement of a gale does not fall within the hours of attendance at the Telegraphic Office and at the Meteorological Office, which practically only extend from 8 A.M. till 3 P.M., much time will be lost in sending news of the fact to London. If it commences at 6 P.M. at Valencia, we cannot hear of it in London till 9 A.M. next morning.

On the other hand, if the observer be living in a sheltered spot such as Plymouth, Nairn, or Greencastle, we shall not get a true report of the gale at all, inasmuch as the observer will not have felt it himself.

The first-named defect in our system can only be met by a considerably increased expenditure on the service, and that is not a scientific, but an administrative question, with which the Government can alone deal.

In order to meet the second difficulty, Mr. De La Rue has kindly devised an instrumental arrangement by which the fact of any given force of wind having been reached at an exposed point (such as Rame Head for Plymouth, or Malin Head for Greencastle) can be at once conveyed to the reporter in his own office, or even to the central office in London. The instrument has been made by Messrs. Negretti and Zambra.

The following is the construction of the new signalling-anemometer:—

To the ordinary Robinson's anemometer-spindle is affixed a toothed wheel, which is geared with another and larger toothed wheel, fixed on a second vertical spindle, carrying a centrifugal governor. The governor-spindle is made to rotate at one half or one third of the velocity of the anemometer-spindle, in order that the rods carrying the governor-balls may not have to be made inconveniently short. A provision is made for adjusting the length of the arms of the governor, so that different wind-velocities may be indicated within certain limits.

The governor-balls act in the well-known way, and expand when driven at a given rate; and the upward motion of these governor-balls is used to raise a secondary wheel to bring into gear a third spindle, on which is fixed the armature of a magneto-electric apparatus, which, like Sir Charles Wheatstone's instruments, consists of a compound permanent magnet with four soft iron cores, two of which are mounted on the N. pole of the magnet and two on the S. pole; these iron cores are surmounted with fine insulated copper wire, and on rotation of the armature give alternately + and — currents in rapid succession, according to the rate at which the armature is driven. These currents are converged inland to the observing-station by insulated wires and give warning by ringing an alarum as long as the anemometer-cups are revolving at a velocity sufficient to raise the governor-balls so as to bring the magneto-electrical apparatus into gear.

We see, therefore, that by adjusting the governor of the apparatus to indicate any required speed, a warning will at once be given when the wind reaches that speed, be it that of 60, 40, or 20 miles an hour, as may be required.

All the attention which the instrument requires, after the apparatus is fixed, is to lead two insulated wires from the anemometer into the observing-station, and to connect these wires to the two terminals on the alarum.

In order to enable the observer to communicate at once, and at as little expense as possible, to London the fact of the velocity in question having been reached, the individual stations might be known by letters or symbols, which might simply be telegraphed to London as an announcement that the alarum was acting at the station in question.

It is obvious that this plan is exceedingly simple; and there seems little reason why it should not be thoroughly efficacious, if only the registering portion of the apparatus can be properly protected from wilful damage by mischievous persons.

As usual, we are met by the question of cost, not only of the apparatus, but of the connecting wires, and last, though not least, of the transmission of the messages. To enable us to render our service more effective than it is, we must be

supplied with the sinews of war. The £3000, which is the very utmost we expend annually on telegraphy, including salaries, rent, and every item, is but small compared with the £50,000, *entirely exclusive of salaries*, with which the chief Signal Office of the United States is so munificently endowed.

On the Meteorology at Banbridge for ten Years, and Rainfall of Ulster. By JOHN SMYTH, *Jun., A.M.*

Banbridge lies in the valley of the Bann, 20 miles from its source, lat. 54° 23′ N., long. 6° 18′ W., height above sea-level 200 feet. Meteorological observations have been carried on since 1861; tables of the results of these and diagrams of the thermometer-stand and rain-gauge were exhibited. The mean pressure of the atmosphere for ten years is 0·133 less than that of Greenwich for 32 years. June has the highest mean monthly pressure and January the least. The year 1870 shows the highest mean annual pressure, and 1872 the least. The mean temperature of the air is 48° F., or 1°·2 below that of Greenwich for 15 years. July has the highest mean monthly temperature, viz. 59°·2, or 2°·5 below that of Greenwich. January has the lowest, 38°·4, or 0·3 higher than Greenwich; February is 2° higher. The winters are therefore warmer, and the summers cooler than at Greenwich. The highest reading of the thermometer was 83° F. on August 4th, 1868, the lowest 11° on January 3rd, 1867. The mean humidity is 82 per cent. of complete saturation, being 0·4 drier than Greenwich. June is the driest, and January the dampest month; February and March are respectively 2 and 3 per cent. drier at Greenwich, and all the other months, except July, November, and December, damper than at Banbridge, June and October being 3 per cent. The prevailing winds have been from the south, and the least frequent from the east. The mean rainfall for the ten years, from 1862 till the end of 1871, has been 29·2 inches; October shows the greatest rainfall and June the least. The rainfall for the year 1872 is the greatest recorded (46·6), and for 1864 the least (25·1); the greatest fall in 24 hours was 2·3 inches, in October 1865. The mean evaporation is 15·6 inches.

At the Bann Reservoir, lat. 54° 15′ N., long. 6° 2′ W., height above sea 440 ft., the mean rainfall was 46 inches, the greatest in 1866 (54·6 inches) and the least in 1869 (28·9 inches); in the exceptional year 1872 the fall was 61·2 inches; the greatest fall in 24 hours was 3·3 inches on October 29th, 1865. The author ceased observing the amount of ozone in 1873, as he found always when the same volume of air was examined by means of an aspirator, the same amount of ozone was registered, except when the test-paper was damped by fog; he was led to expect this from finding the intensity of the wind correspond with the intensity of the ozone, as observed in Clarke's cage (this subject is treated more at large by him in a paper read before the Association in 1865).

Rainfall of Ulster.—The amount of rainfall at the various stations, as obtained from Mr. Symons, were shown on the map exhibited. It was seen that they are rather few and unequally distributed, and that the westerly show greater falls than the easterly. There is great variety in the physical configuration of Ulster, and it is hoped that more observers will be obtained. Our present data are not sufficient to enable us to arrive at exact results.

On the Absorption of the Sun's Heat-rays by the Vapour of the Atmosphere. By* the Rev. FENWICK W. STOW, *M.A., F.M.S.*

The observations of solar radiation, which are relied on in this paper, are taken with "blackened-bulb thermometers *in vacuo*," suspended 4 feet above the ground, the indications of which, when compared with those of the ordinary shade thermometers, give a measure of the intensity of the solar rays.

The absorption of the direct solar heat-rays by the vapour of the atmosphere is proved in several distinct ways:—

1. It is found that the elastic force of vapour is less on the ten days in each month on which radiation is most powerful than on an average of the whole month.

* Printed *in extenso* in the 'Journal of the Meteorological Society' for 1874.

This is proved by five years' daily observations at Strathfield Turgiss, Hants, 1869–74; two years' at Hawsker, near Whitby, Yorkshire (1869–71); and one year's observations in 1872, at Harpenden, Herts.

2. It was also found by the above observations that N. and N.W. winds, which contain little moisture, are very favourable to solar radiation, whereas S. and S.E. winds are usually accompanied by much less powerful sunshine. The N.E. winds of spring, which are excessively dry, are also accompanied by intensely powerful solar radiation.

3. By frequent observations during cloudless weather with nearly constant vapour-tension, curves are obtained representing the daily variations in solar radiation produced by the changes in the sun's altitude and consequent alteration of the length of the path which the beams pursue through the atmosphere. From these the percentage of the sun's heat-rays which would be absorbed by the atmosphere if the sun were vertical can be approximately determined, assuming that the tension of vapour remained as it was on the day or days of observation. It is then possible to calculate the amount of radiation due to the altitude of the sun at noon in the middle of each month for a constant vapour-tension, and to compare this with the amount actually observed in each month on cloudless days. In this way it is found that when the tension of vapour falls below the amount on the day which furnishes the data for calculation, the radiation rises above the calculated amount, and *vice versâ*. In fact the sun's rays are more intense in winter than in summer, when the difference of altitude at noon is allowed for, because the absolute amount of vapour in winter is so much less. About ten or twelve per cent. is the minimum of absorption of the sun's heat-rays, while the maximum equals or even exceeds 20 per cent.

The paper concludes with a few observations on the increase of solar radiation with elevation above the sea-level, from which it would appear to have amounted, between the heights of 470 to 1800 feet, to about 5 per cent. of the amount observed at the lower station when the sun's altitude was 20°, and to above 3 per cent. when the altitude was 26°.

On the Necessity for placing Physical Meteorology on a Rational Basis. By* Lieut.-Col. A. Strange, *F.R.S.*

The author points out the two great branches into which the science of meteorology is divisible, viz. that which is concerned with its great fundamental laws, and that which concerns climate—the first being of a cosmical, the second of a more local character. The present paper refers principally to the first of these branches, which he considers to have been greatly neglected, and to need being treated on systematic and rational principles.

He indicates the elementary considerations which point to the sun as the chief origin of meteorological phenomena, and recommends, now that science has provided many of the necessary means for the purpose, that the physical study of the great central luminary should be commenced in earnest.

He points out that such solar researches as have been undertaken, though most valuable as far as they go, are insufficient because their continuity is interrupted by cloudy weather. He holds that we require a daily record of the changes which are perpetually going on in the sun, in order to trace their course, their character, and their laws. He points out that this indispensable object can only be attained by establishing a certain number of stations, equipped for such rssearches, so situated that there shall be a fair probability of clear weather daily at one or more of them. He mentions India as peculiarly suited for the purpose on account of the great variety of climate to be found there.

He maintains that such investigations must devolve on the State, and lays down the broad principles applicable to the particular case in question. The first principle is that private enterprise should, in all matters within its scope, be encouraged and aided in every possible way. The second principle is that the State should step in where private enterprise fails, and itself conduct scientific research, whether observatorial or experimental, subject to the following main conditions:—

* Published in 'Nature,' vol. x. p. 490 (Oct. 15, 1874).

(*a*) That the probable results of the research will be beneficial, in the widest sense of that term, to the community at large, or to the various Departments of the State.

(*b*) That the research is too costly, or commercially too unremunerative, to be undertaken and vigorously prosecuted by individuals.

(*c*) That the research requires continuous uninterrupted work, extending over very long periods, and conducted by systematically organized establishments.

The case under consideration completely satisfies these conditions. It is futile to expect that individuals will carry on continuously work which requires numerous well-equipped establishments conducted on a uniform system, the operations of which will certainly extend over generations, possibly over centuries.

Whilst advocating the study of the sun as the rational basis of meteorology, the author does not desire to abandon those methods of observation now in use, though they admit of improvement; but he likens meteorology, as at present prosecuted, to studying the steam-engine without giving any attention to the furnace and boiler.

On the Relative Sensitiveness of Thermometers differing in Size, Shape, or Materials. By G. J. Symons, *Sec. Met. Soc.*

The author exhibited a series of 14 very carefully made thermometers, all differing either in the size or shape of the bulbs, or in the materials with which they were filled, some being filled with mercury and some with alcohol. They had been specially constructed with a view to testing the relative sensitiveness of different patterns and sizes. The results of the experiments had been printed in the 'Quarterly Journal of the Meteorological Society,' and were briefly the following:—that very large spherical mercurial bulbs are very little better than those filled with alcohol, but that with small bulbs mercury is much the most sensitive. The new minimum thermometers (the bifurcated and the double cylinder) introduced respectively by Mr. Casella and Mr. Hicks, were highly praised. The author said that he brought them before the Section mainly in order to offer the loan of the entire series to any experimentalist, with more leisure than himself, who would develop and complete the inquiry which he had begun.

On a New Form of Rain-gauge. By G. J. Symons, *Sec. Met. Soc.*

The author exhibited and explained a new form of rain-gauge designed by himself to facilitate accurate observations of the rate at which rain falls in heavy storms, and thus supply data on a subject of equal interest from a meteorological and engineering point of view. The arrangement is extremely simple. The rain is collected in a funnel 8 inches in diameter, is then led into a cylinder in which a copper float rests on a water-surface. As rain falls the float rises, and a fine cord passing round a horizontal axis causes it to revolve once for each inch of rain. At one extremity of this axis are two hands attached to separate wheels of such diameter, that while one revolves only once the other revolves five times. The former is the one attached to the axis, and thus one hand completes a rotation for one inch, and the other for five inches. Behind these hands is an opal-glass dial about one foot in diameter; so that the appearance of the instrument is that of a clock, the minute- and hour-hands being replaced by hundredths of an inch and inches. The resemblance is carried further by the fact that arrangements have been made for the dial being illuminated at night by gas or oil. The author expressed much satisfaction with the way in which his design had been carried out by the maker, Mr. Pastorelli.

Instruments &c.

On an Apparatus for showing the Interference of Sound. By Prof. W. F. Barrett.

On Improvements in Equatorial Clocks. By Howard Grubb.

Description of a Trompe or Blowing-Engine for giving a supply of Coal-gas under Pressure for Sensitive Flames. By F. HERBERT MARSHALL.

The apparatus consists of a modification of the ordinary Catalan Trompe, whereby pressure is imparted to a stream of gas by the velocity of a fall of water carrying the gas with it.

A vertical glass tube, 6 feet long and $\frac{1}{2}$-inch bore, is enlarged in a funnel-shape at the top to about $1\frac{1}{4}$ inch; into this fits tightly a cork through which pass two tubes of about $\frac{1}{4}$ inch internal diameter, connected, one with the water-main and the other with the gas-main, the tubes passing just through the cork on the inside.

The lower end of the large vertical tube passes through an air-tight cork to within an inch of the bottom of a 3-pint bottle.

A siphon with india-rubber connexion and a screw pinch-cock, having a rather larger bore than the vertical tube, passes into the same bottle, as far removed from the principal tube as possible, and leads to a sink or waste-pipe.

A third tube of about $\frac{1}{4}$-inch bore passes through the cork about $\frac{1}{2}$ inch into the bottle: this tube is connected with the sensitive jet, either directly or, better, with the intervention of a regulator in which a few inches of benzol take the place of the water usually employed in such apparatus. The regulator should be large, and the tube leading into it rather less than $\frac{1}{4}$-inch bore, to obtain greater steadiness of flame.

The working of the apparatus is frequently improved by inserting a loose piece of glass tube, about $\frac{1}{2}$ inch long and of such diameter as to remain supported in its position, at the point where the long vertical tube begins to expand. The check imparted to the stream of water by this contraction seems to assist the formation of water-pistons, so to speak, in the principal tube, instead of allowing the water to flow down the sides of the tube in a film without carrying gas with it, as sometimes happens if the supply of water be not sufficient.

The connexions being made, and all joints air-tight, water and gas are turned on from the mains, and the siphon started in action by holding the finger on the sensitive jet for a moment. When all air is expelled from the bottle and regulator, the gas is lighted, and the flame is adjusted to any desired degree of sensitiveness by regulating the supply of water and gas and the outflow from the siphon, care being taken to keep 2 or 3 inches of water in the bottle.

On the Adoption (for the general purposes of Navigation) of Charts on Gnomonic Projection instead of on Mercator's Projection. By G. J. MORRISON.

I.

1. The great circle course or shortest distance between any two points on the earth's surface is shown by a straight line on the chart. By means of a ruler, therefore, it is easy to find out in one moment the position of the great circle track along the whole course from point to point, and thus to see at a glance if there be any obstacles in the way, whereas the plotting of a great circle track on a Mercator chart involves the expenditure of a great deal of time and trouble.

2. When it is impossible to adopt the great circle course on account of obstacles in the way, it is easy in a few moments to lay down the best practicable course, whereas it is very difficult to do so on a Mercator chart.

3. The measurement of distances on a Mercator chart is somewhat difficult, whereas on these maps distances can be measured with a transparent scale or a pair of compasses in a few moments.

4. The relative position of the various points on the earth's surface is more correctly shown on these maps than on those of Mercator.

The great circle course appears to be the shortest and natural route, whereas on an ordinary chart it appears to be much longer than the Mercator route, and seamen get a better idea from these charts of the proper route to follow than they do from a Mercator chart.

II.

It may be objected that:—

1. Only a small portion of the earth can be got on one sheet, and there is a difficulty in drawing a great circle course between points situated on separate sheets. This is true; but by taking some pains in arranging the maps, as has been done in this case, and by repeating portions of the earth on two or more sheets, matters have been so arranged that scarcely any voyage can be named in which the ports of arrival and departure cannot be found, either on the same sheet or on opposite sheets, in either of which cases the course can be laid down instantly; and even in the rare case of two ports being found on adjacent sheets only, the course can be laid down infinitely more easily than it can on a Mercator chart.

2. It is impossible to find the bearing of one point from another, as can be done on the Mercator chart by a compass and a parallel ruler.

This really is no disadvantage. No one ought to sail along a curved course, and no one need care to know any thing about such a course. If this objection be seriously urged, it only proves that Mercator's charts have put false ideas into people's heads, and that other charts are required to replace them.

Negretti and Zambra's Patent Recording and Deep-sea Thermometer.
By HENRY NEGRETTI.

This thermometer differs from all other registering or recording thermometers in the following important particulars:—

1. The thermometer contains only mercury without any admixture of alcohol or other fluid.

2. It has no indices or springs, and its indications are by the column of mercury only.

3. It can be carried in any position, and cannot possibly be put out of order except by actual breakage of the instrument.

And, lastly, it will indicate and record the exact temperature at any hour of the day or night, or the exact temperature at any depth of the sea, irrespective of either warm or cold currents or stratum through which the thermometer may have to pass in its descent or ascent; this last very special quality renders this thermometer superior for deep-sea temperatures to any others; those which are now used in the 'Challenger' sounding-expedition are liable to give erroneous indications, because their indices may slip and they may become otherwise deranged; and *under certain conditions of temperature* it is not possible by the old thermometers to obtain true temperatures at certain depths. Prof. Wyville Thomson says, in his work 'Depths of the Sea':—

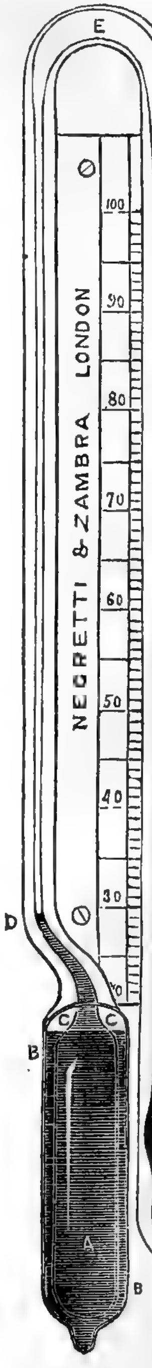
"I ought to mention that in taking the bottom temperature with Six's thermometer the instrument simply indicates the lowest temperature to which it has been subjected, and not necessarily that of the bottom itself;" and in confirmation Mr. Negretti quoted a report to the Admiralty from Captain G. S. Nares, of H.M.S. 'Challenger,' dated Melbourne, March 25, 1874:—

"At a short distance from the pack, the surface-water rose to 32° F., but at a depth of 40 fathoms we always found the temperature to be 29°; this continued to 300 fathoms, the depth in which most of the icebergs float, after which there is a stratum of slightly warmer water of 33° or 34°. As the thermometers had to pass through these two belts of water before reaching the bottom, the indices registered those temperatures, and it was impossible to obtain the exact temperature of the bottom whilst near the ice, but the observations made in lower latitudes show that it is about 31°. More exact results could not have been obtained even had Mr. Siemens's apparatus been on board."

The thermometer described, the author believes, will be found free from the defects of the thermometers now in use in the 'Challenger' and other sounding-expeditions.

The bulb of the thermometer is protected so as to resist the pressure of the ocean, which varies according to depth, that of three thousand fathoms being about three

tons pressure on the square inch. The manner of protecting the bulb was invented by Messrs. Negretti and Zambra in 1857 (at which time a number were made for the late Admiral FitzRoy), and has been lately copied and brought out as a new invention by other persons.



The construction of the instrument for deep-sea temperatures is as follows:—

In shape it is like a siphon with parallel legs, all in one piece and in continuous communication. The scale of the thermometer is pivoted on a centre, and being attached in a perpendicular position to a simple apparatus, is lowered to any depth that may be desired. In its descent the thermometer acts as an ordinary instrument, the mercury rising or falling according to the temperature of the stratum through which it passes; but so soon as the descent ceases, and a reverse motion is given to the line, so as to pull the thermometer towards the surface, the instrument turns once on its centre, first bulb uppermost, and afterwards bulb downwards. This causes the mercury, which was in the left-hand column, first to pass into the dilated siphon bend at the top, and thence into the right-hand tube, where it remains, indicating on a graduated scale the exact temperature at the time it was turned over. The woodcut shows the position of the mercury *after* the instrument has been thus turned on its centre. A is the bulb; B the outer coating or protected cylinder; C is the space of rarefied air, which is reduced if the outer casing be compressed; D is a small glass plug on the principle of Negretti and Zambra's Maximum Thermometer, which cuts off, in the moment of turning, the mercury in the tube from that of the bulb, thereby ensuring that none but the mercury in the tube can be transferred into the indicating column; E is an enlargement made in the bend so as to enable the mercury to pass quickly from one tube to another in revolving; and F is the indicating tube or thermometer proper. In its action, as soon as the thermometer is put in motion, and immediately the tube has acquired a slightly oblique position, the mercury breaks off at the point D, runs into the curved and enlarged portion E, and eventually falls into the tube F when this tube resumes its original perpendicular position.

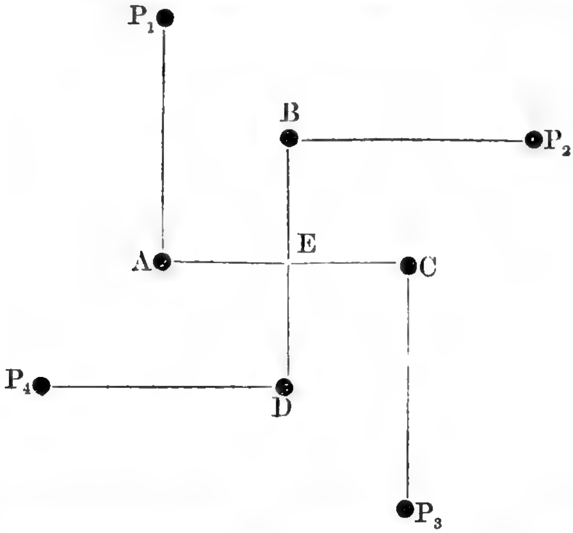
The contrivance for turning the thermometer over in the sea, either at the bottom or at any depth which may be desired, may be described as a vertical propeller to which the thermometer is pivoted; this is fixed to a line, and as long as the apparatus is descending the propeller remains still; but as soon as the line is pulled up and the ascent commences, it begins to revolve and continues to do so until the thermometer is turned over (which it does in less than two fathoms), and then remains fixed and immovable.

For atmospheric purposes and observatories the thermometer is turned over by means of a simple clockwork; two thermometers fitted as hygrometers can be turned over as easily as one; and it is suggested that this instrument might supersede the large, cumbersome, and expensive thermographs at present in use.

A Four-Pendulum Apparatus. *By* S. C. Tisley.

At the Bradford Meeting the author described a two-pendulum apparatus for drawing rectangular harmonic curves. In the construction of that apparatus two defects were present—each vibrator working on the other as a centre, the tracer described portions of two circular arcs; but when each was vibrated separately,

instead of straight lines, it gave the resulting figures a peculiar twist. To overcome this defect a double link motion has been adopted:—



AB and CD are two rods moving freely on their centre, E. At the points A, B, C, and D are ball-and-socket joints connected with the tops of four pendulums, P_1, P_2, P_3, P_4, by means of wire arms.

The pendulums can be set in motion either in pairs or in threes or all four at once, the resulting motions of the tracer E producing very curious figures.

By this arrangement, if the two opposite pendulums (say P_1 and P_3 or P_2 and P_4) are set in motion, the other two being fixed, and a strip of paper drawn under the tracer, a modification of the curves described by Mr. A. E. Donkin in last year's Report will be produced.

CHEMISTRY.

Address by Professor A. Crum Brown, *M.D., F.R.S.E., F.C.S., President of the Section.*

One hundred years have elapsed since the discovery of oxygen by Priestley. Perhaps we should say rediscovery, for there is no doubt that about one hundred years earlier Mayow prepared from nitre nearly pure oxygen, and observed and recorded some of its most marked properties. Mayow's discovery, however, led to nothing, while Priestley's was the most important step in that reconstruction of speculative chemistry which was commenced by Black and carried on with surprising energy and thoroughness by Lavoisier and his associates. I shall not detain you by enumerating the ways in which this discovery has affected chemistry both practical and speculative. The preeminent position to which oxygen was at once elevated, and which it so long retained, makes this altogether unnecessary. I wish, however, to point out one character of the phlogistic controversy which sharply distinguishes it from many others. The truth represented by the theory of Phlogiston was not recognized with sufficient distinctness by the supporters of that theory to give them any chance of success in opposition to a band of devoted adherents of a view which was clearly understood by all. The phlogistists were completely defeated, and the theory ceased to exist. It has been left for chemical antiquaries to pick out, with difficulty and uncertainty, a meaning from the ruins.

I have mentioned this character because I wish to draw your attention to another more recent controversy, the result of which was very different.

The questions as to chemical constitution raised about forty years ago by Dumas and the new French school, in opposition to Berzelius, may now be said to be practically settled. The great majority of chemists are agreed as to what is to be understood by chemical constitution, and also as to the nature and amount of evidence required in order to determine the constitution of a substance. How has this agreement been produced? Some historical writers seem to wish us to believe that it is the result of the triumph of the ideas of Dumas, Gerhardt, and Laurent, and the defeat of the dualistic radical theory of Berzelius; that the arguments of Berzelius and his followers were only useful as giving occasion for a more full and convincing proof of the unitary substitution theory than would otherwise have been called for; that, in fact, the adherents of Dualism played the part (not unfrequently supposed to be that of the conservative party in politics) of checking and criticising the successive developments of truth, and thus allowing them time to ripen.

In opposition to the view thus broadly stated, I would place another, and for the sake of contrast shall state it also in perhaps too broad a form. That the two theories, the dualistic radical theory and the unitary substitution theory, were both true and both imperfect, that they underwent gradual development, scarcely influenced by each other, until they have come to be almost identical in reference to points where they at one time seemed most opposed.

I have said that the development of the one theory was scarcely influenced by that of the other. Of course the *facts* discovered by both parties were common property, and the development of both theories depended upon the discovery of these facts; but the explanations of facts and the reasoning from them given by each party seemed to the other scarcely worthy of serious consideration and were treated as matter of ridicule. And the habit of mind created by this mode of viewing the opposed theory has rendered it difficult for those who were engaged in the controversy on either side to see how nearly the two theories have now come to coincidence. Their language still remains different; but as the facts are the same for both, it is not difficult for a neutral critic to translate from the one to the other; and if we do so we shall see that there is much real agreement between the two modes of representing chemical ideas, historically derived, the one from Berzelius, the other from Dumas, Laurent, and Gerhardt.

In both, chemical constitution is regarded as *the order in which the constituents are united in the compound*; and the same fundamental notion is indicated in the one by reference to proximate constituents, in the other by the concatenation of atoms. To show that this is so, and that the fundamental notion can be arrived at from the dualistic as well as from the unitary starting-point, I shall cite an illustrative case. Every student of chemical history will remember the view of the constitution of trichloracetic acid propounded by Berzelius, and afterwards supplemented by a similar view of the constitution of acetic acid and an explanation of the likeness of some of the properties of these two substances. This has sometimes been spoken of as a subterfuge of a not very creditable kind, by means of which Berzelius apparently saved his consistency while really yielding to the arguments of his opponents. But if, instead of looking at it in the light of the substitution controversy, we consider it in itself as a contribution to speculative chemistry, we at once recognize in it a statement, in Berzelian language, of the views we now hold as to the constitution of these acids. The view was that acetic acid is a compound of oxalic acid and methyl, trichloracetic acid a compound of oxalic acid and the sesquichloride of carbon. They differ considerably from each other, because the "copulæ" (methyl and sesquichloride of carbon respectively) are different; but their resemblance is strongly marked because they contain the same active constituent, oxalic acid; and most of the prominent characters of the substances depend upon it, and not upon the copula. Let us first free this statement from what we may call archaisms of language. It will then assume something like the following form:—The carbon in acetic acid is equally divided between two proximate constituents, one of which is an oxide, the other a hydride of carbon. Trichloracetic acid similarly contains an oxide and a chloride of carbon, between which the carbon is equally divided. The oxide is the same in both acids, and is that oxide which occurs in oxalic acid. The hydride and the chloride have the composition of the substances, the formulæ of which are $C_2 H_6$ and $C_2 Cl_6$ respectively. Oxalic acid undergoes chemical change much more

readily than the corresponding hydride or chloride; and therefore the chemical character of acetic and of trichloracetic acids depends much more on the oxidized than on the other constituent, and they thus have a marked resemblance. The oxidized constituent is united to the other in a manner different from that in which oxalic acid is united to bases in the oxalates, inasmuch as, while the basic water of hydrated oxalic acid is displaced when oxalic acid unites with a base, in hydrated acetic and trichloracetic acids there is the same proportion between the basic water and the oxidized carbon as there is in oxalic acid.

Now has not this a great resemblance to the view entertained by most modern chemists, that acetic acid is a compound of the radical carboxyl (half a molecule of oxalic acid) and the radical methyl (half a molecule of methyl gas), that trichloracetic acid similarly contains the same radical carboxyl and the radical $C\,Cl_3$, and that the prominent chemical properties of these bodies depend upon their containing carboxyl, and that they therefore resemble each other?

The modern view contains nothing inconsistent with that of Berzelius; but it no doubt contains something more: it contains an explanation of the difference between the manner in which carboxyl is united to methyl in acetic acid, and the manner in which oxalic acid is united to bases in the oxalates. But it will surely be admitted that Berzelius was here far ahead of his opponents—so far ahead, that they altogether failed to see his meaning, and looked upon his argument as a clumsy device.

The treatment by Berzelius of the constitution of the sulpho-acids furnishes a precisely similar case. These are now regarded as compounds of the radical $SO_2\,OH$ (which we may call sulphoxyl). This radical is half a molecule of hyposulphuric acid; and Berzelius considered them coupled compounds of hyposulphuric acid, adopting at once the view first brought forward by Kolbe in his classical memoir on the sulphite of perchloride of carbon and the acids derived from it.

I might pursue the history of the carbon- and sulpho-acids further, and trace the development of the theory of their constitution through the discoveries of Kolbe, and his beautiful application to the cases of carbon and sulphur of Frankland's far-sighted speculation on the constitution of the organo-metallic bodies, pointing out the relation of Kolbe's views of the constitution of acids, alcohols, aldehydes, and ketones to the Berzelian theory on the one hand, and to the opinions of modern chemists on the other; but the greater part of such an historical sketch has been given very recently by Kolbe himself in the 'Journal für praktische Chemie,' and I may therefore omit it.

It would be easy to bring forward cases to show that our present views can be directly derived from the substitution theory and the types of Dumas and Gerhardt, through the complications of multiple and mixed types and the labyrinthine formulæ to which these gave rise, to the wonderfully simple and comprehensive system of Kekulé; but that is unnecessary, as this development has been fully and ably described by more than one thoroughly competent writer.

We have been discussing a case in which Berzelius was right in considering a compound of carbon, oxygen, and chlorine as composed of two parts—an oxide and a chloride of carbon. It is only just that we should take some notice of cases, at first sight similar, in which modern chemists would be inclined to think that he was wrong. This is the more necessary, as an examination of these cases will enable us to see what was the really valuable contribution made to speculative chemistry by the substitution theory.

Compounds containing three elements were formulated in two different ways by Berzelius:—

1st. One of the elements was represented as combined with a radical composed of the other two, as:—hydrocyanic acid, $H_2 \,.\, C_2 N_2$; ether, $C_4 H_{10} \,.\, O$.

2nd. The ternary compound was represented as composed of two binary compounds, having one element common, as:—caustic potash, KO, H_2O; chromochloric acid, $2Cr\,O_3, Cr\,Cl_6$.

Phosgene gas was at first formulated in the former of these ways as CO, Cl_2; but latterly he was forced, in consistency, to give up all radicals containing oxygen or other strongly electro-negative element*, and to write the formula of phosgene gas

* In 1838 Berzelius was inclined to regard $C_2\,O_2$, to which he gave the name "oxatyl," as the radical of oxalic acid and oxamide.

CO_2, $C\,Cl_4$. Similarly, in every case where a positive element or radical is combined with two negative elements or radicals, he represented the compound as composed of two binary compounds, thus—chloride of acetyl, $2C_4\,H_6\,O_3$, $C_4\,H_6\,Cl_6$, as a compound of acetic acid and the corresponding terchloride.

This was in perfect consistency with the mode in which ternary compounds containing one negative and two positive elements or radicals were formulated, as caustic potash, KO, $H_2\,O$, sulphate of copper, CuO, SO_3, &c.; but it lacks the practical justification which can be given for the formula $C_2\,H_6$, $C_2\,O_3$ for acetic acid; for phosgene acts readily on water, forming carbonic and hydrochloric acids, an action which does not take place with perchloride of carbon; and it is not easy to see why the latter substance should be more readily attacked by water when combined with carbonic acid than when free. This difference did not escape the attention of Berzelius, and led him to distinguish two modes of chemical union:—1st. Where the constituents were held together by the electro-chemical force, and wholly or partially neutralized each other, as in the oxygen and sulphur salts; and 2nd, where a so-called "copula" was attached by an unknown force to a substance without greatly modifying its chemical activity. The distinction seems arbitrary; but it was not, as is usually supposed, a mere artificial bulwark to protect the electro-chemical theory; it has a real and very important meaning, a meaning which the development of the substitution theory enables us to explain.

The phenomena of electrolysis, upon which the Berzelian system is based, bring forward into great prominence *one* of the chemical units, viz. the *equivalent*; and the preeminent position of oxygen as the most electro-negative element made it most natural to select the atom of oxygen as the standard of equivalence, so that an equivalent of any element or radical was defined as that quantity of it which is equivalent to one atom of oxygen. Gay-Lussac's law of gaseous volumes, which was adopted by Berzelius, and which, by a curious accident, happens to be true for all elements gaseous at ordinary temperatures, led to the formulæ H_2 and Cl_2 for the *equivalents* of hydrogen and chlorine; but although these formulæ explicitly indicate the divisibility of the equivalents of these elements, this divisibility was not recognized, and integral numbers of equivalents were alone tolerated. Thus hydrochloric acid was written $H_2\,Cl_2$, ammonia $N_2\,H_6$, &c., and the etymological meaning of the word atom was soon lost. The use of barred letters to indicate two atoms or one equivalent of such elements as hydrogen and chlorine further contributed to hide the important fact of their divisibility.

The first great result of the substitution theory was to change the unit of equivalence, and to take as the standard the atom of hydrogen or of chlorine instead of that of oxygen; and although it would be most unjust to forget the services of Dumas, Gerhardt, Laurent, and Odling in this matter, the credit of removing the bars from H, Cl, and their comrades, and allowing the hitherto chained partners to walk at liberty, undoubtedly belongs mainly to our distinguished colleague and master Professor Williamson.

The establishment of the water type, or (to put it in another form) the proof that the atom of oxygen contains two units of oxygen, inseparably united but capable of separate action, led the way to the explanation of all the difficulties which beset the theory of radicals and copulæ. It at once explained how two oxides or two sulphides unite together*; and the idea of "polybasic," or, as we should now say, polyad atoms and radicals, was soon used to explain the existence of polybasic acids, double salts, acichlorides, and many other kinds of ternary compounds.

But a fact does not cease to exist because it is explained. Quicklime and water unite together, although we can now explain how they do so; and a useful purpose may still be served by the enumeration, as in the old dualistic formulæ, of the pairs of united equivalents. Although some of these equivalents belong to the same atoms, it is nevertheless true that they are united in pairs. Caustic potash might thus be formulated, $KO_{\frac{1}{2}}$, $HO_{\frac{1}{2}}$ or $\frac{1}{2}(K_2O, H_2O)$; phosgene gas, $\frac{1}{2}(CO_2, CCl_4)$; and chlorochromic acid, $\frac{1}{3}(2CrO_3, CrCl_6)$. These formulæ are not so well suited for general use as those now current; but the consideration of them as accurate representations of facts may enable us to see that the copulæ of Berzelius had a real and

* It does not explain the existence of double chlorides, bromides, &c. These compounds, apparently so similar to the double oxides and sulphides, are still unexplained.

valuable meaning. Take, for instance, the formula of acetic acid, $H_3C—CO—OH$, or $\frac{3}{4}CH_4$, $\frac{3}{4}CO_2$, $\frac{1}{2}H_2O$, $\frac{1}{4}C_2$; it is this last term which indicates the coupled character of the compound. If we look upon acetic acid as a compound of carbon, it is a coupled compound because all the equivalents of carbon in it do not belong to the same atom, and the two atoms of carbon are directly united together, and replacement of the equivalents united to one of these atoms does not very greatly affect the function or chemical character of the equivalents united to the other.

I have perhaps spent too much of your time upon these historical questions. Let us now shortly consider what is the present state of our knowledge as to chemical constitution. This I have already defined as the order in which the constituents are united in the compound. We may indeed use metaphorical language, and speak of the relative position of atoms, perhaps deluding ourselves into the notion that such language is more than metaphorical; but the phenomena of combination and decomposition, although we cannot doubt that they depend solely upon the relative position and dynamical relations of the atoms, are not alone sufficient to prove even that atoms exist. Our knowledge of the intimate structure of matter comes from another source—from the study of the properties rather than of the changes of substances, and of the transformations of energy which accompany the transformations of matter.

This is strictly a branch of Chemistry: the aim of chemistry is to connect the properties of substances and the changes they undergo with their composition, taking this word in its widest sense; and we must not allow our friends in Section A to cut our science in two and appropriate the half of it. We all frankly admit that Chemistry is a branch of Physics; but it is so as a whole—no section of it is more purely physical than all the rest. To accept a narrower definition of Chemistry is to reduce ourselves to the position which the collector occupies among naturalists; it is to admit that it is our business to provide part of the materials out of which a science in which we have no share may be constructed by others. But we need not fear that this so-called physical side of Chemistry will ever be divorced from the study of chemical change. The names of Faraday and Graham among those who have left us, of Andrews among those who are still at work, are sufficient proof of this; and a study of their researches will conclusively show that great results can be looked for in this direction only from a physicist who is also a chemist.

There are three special directions in which such investigations have already influenced chemical theory:—1st. *Electrolysis*, which has confirmed the equivalent as a chemical unit, has proved that equivalents unite in pairs, thus forming the basis of the electro-chemical theory, and has shown us how to estimate the amount of energy involved in the union of a given pair of equivalents. 2nd. *Vapour-density*, from which Avogadro inferred the law of molecular volumes (since proved by Clerk-Maxwell), which has given us the molecule as a chemical unit, and formed the basis of the Unitary theory. 3rd. *Specific heat*, from which Dulong and Petit inferred their empirical law, which gives us the most satisfactory physical definition of the atom as a chemical unit.

We naturally turn to the future, and try to guess whence the next great revolution will come. For although periods of quiet have their use, as affording time for filling up the blank schedules furnished by the last speculative change, such periods have seldom been long, and each has been shorter than its predecessor.

But it is impossible to make a certain forecast: looking back, we see a logical sequence in the history of chemical speculation; and no doubt the next step will appear, after it has been taken, to follow as naturally from the present position. One thing we can distinctly see—we are struggling towards a theory of Chemistry. Such a theory we do not possess. What we are sometimes pleased to dignify with that name is a collection of generalizations of various degrees of imperfection. We cannot attain to a real theory of Chemistry until we are able to connect the science by some hypothesis with the general theory of Dynamics. No attempt of this kind has hitherto been made; and it is difficult to see how any such attempt can be made until we know something in reference to the absolute size, mass, and shape of molecules and atoms, the position of the atoms in the molecule,

and the nature of the forces acting upon them. Whence can we look for such knowledge?

The phenomena of gaseous diffusion, of gaseous friction, and of the propagation of heat through gases have already given us an approximation to the size and mass of the molecules of gases. It is not unreasonable to suppose that a comparative study of the specific heat of gases and vapours may lead to some approximate knowledge as to the shape of their molecules; and a comparison of such approximate results with the chemical constitution of the substances may lead to an hypothesis which will lay the foundation of a real theory of Chemistry.

Chemistry will then become a branch of applied Mathematics; but it will not cease to be an experimental science. Mathematics may enable us retrospectively to justify results obtained by experiment, may point out useful lines of research, and even sometimes predict entirely novel discoveries, but will not revolutionize our laboratories. Mathematical will not replace Chemical analysis.

We do not know when the change will take place, or whether it will be gradual or sudden; but no one who believes in the progress of human knowledge and in the consistency of Nature can doubt that ultimately the theory of Chemistry and of all other physical sciences will be absorbed into the one theory of Dynamics.

On the Composition of an Inflammable Gas issuing from below the Silt-bed in Belfast. By Dr. Andrews, *F.R.S.*

In sinking for a well upon the premises of Messrs. Cantrell and Cochrane, in George's Lane, Police Square, Belfast, after having passed through a deposit of silt to the depth of 33 feet, a layer of gravel was reached, 7 feet in thickness, and containing a quantity of organic débris. It rested upon a thick deposit of very tenacious clay. On entering the gravel-bed, a large flow of water occurred, which rose to within 4 feet of the surface of the ground, and interrupted the operation of boring, till a pump, worked by a small steam-engine, was erected, which, so long as it was in action, kept the boring free from water as far as the surface of the gravel-bed. A workman, having lowered a light to examine the bottom of the well, was surprised to see a lambent flame playing over the surface. On examination this was found to arise from a disengagement of inflammable gas, which had accumulated between the lower surface of the bed of silt and the layer of gravel.

An iron pipe, terminating in a funnel-shaped mouth, about one foot in diameter, was now sunk till it reached the gas-stratum; and the water in the well was kept by pumping at such a level that an extra pressure of about one inch of water was maintained upon the gas below. The gas now flowed freely, at the rate of about 40 cubic inches per minute, through the upper end of the iron pipe, and, when ignited, burned with a yellow flame, which could scarcely be distinguished from that of ordinary coal-gas.

Two portions of the gas were carefully collected by displacement, the stream of gas being allowed to pass till the whole of the atmospheric air in the vessels was completely swept away. The connecting tubes were then carefully sealed, and the gas was afterwards analyzed in the laboratory of Queen's College.

A measured volume of the gas, standing over mercury, was exposed to the action, first, of caustic potash, and afterwards of pyrogallic acid, and the residual gas was afterwards analyzed with the following results:—

	V.	T.	B.	C.
Atmospheric air	78·7	12·2	770·6	308·8
After addition of residual gas....	120·5	12·4	771·5	272·2
After addition of oxygen........	190·0	12·8	771·8	221·8
After explosion................	126·5	13·0	771·7	271·6
After action of potash..........	90·0	11·8	772·0	299·7

In this Table V is the volume of the gas, T its temperature in Centigrade degrees, B the height of the barometer in millimetres, and C the height of the mercury in the tube in which the observations were made. From these data, and the results of the previous action of the caustic potash and pyrogallic acid, it follows that the composition of the gas was:—

Marsh-gas ($C\,H_4$)	83·75
Carbonic acid	2·44
Oxygen	1·06
Nitrogen	12·75

The density of the gas (air=1) was found to be 0·661, which corresponds nearly to the foregoing composition. The gas was inodorous, and contained no compound of carbon and hydrogen except marsh-gas.

From this analysis it is evident that the gas formed in this subterranean sheet of water is in all respects the same as that which is produced in stagnant pools containing leaves and other vegetable matters.

On an Aspirator. *By* Dr. Andrews, *F.R.S.*

On the Joint Action of Carbonic Acid and Cyanogen on Oxide of Iron and on Metallic Iron. *By* I. Lowthian Bell, *F.R.S., F.C.S.*

In the operation of smelting iron the reducing agent for all practical purposes is carbonic oxide. The power this substance possesses of depriving an ore of iron of its oxygen is greatly weakened by the presence of the resulting carbonic acid. From my own experiments, it would appear that when one third of the carbon in the gases of a blast-furnace is raised to its highest state of oxidation, further action is so retarded as virtually to place a limit on the economy of fuel in the process in question.

Besides this reducing property exercised by carbonic oxide, there is a second one which, like the former, takes place in the upper and cooler parts of the furnace, viz. the splitting up of itself in considerable quantities into carbon and carbonic acid by contact with iron. This rearrangement of elements is accompanied by an evolution of heat, and at the same time returns a quantity of carbon to the operation. Here also, when carbonic acid exceeds certain limits, this reaction ceases.

In certain smelting-works in Austria, where charcoal is employed, white pig is produced with a smaller quantity of fuel than I would have supposed possible, keeping the law just mentioned in view. This difference might be supposed due to some peculiarity in the ore itself, which was of the spathose variety. It was found, however, when coke was substituted for charcoal in a properly constructed furnace, having a height of 60 feet, the fuel required rose from 14 to nearly 24 cwt. to the ton of metal, which is something more than that required in this country.

In a furnace in the county of Durham, where coke was exclusively used, I found cyanogen combined with sodium and potassium exist in more considerable quantities than had been hitherto suspected. Supposing it possible that these cyanides might be more abundant in charcoal-furnaces, where the fuel is richer in alkaline substances than is the case with mineral fuel, I had the following experiments performed in the laboratory of the Clarence Iron Works by Mr. Rocholl, to determine the effect relatively of carbonic acid in restraining the reducing and carbon-depositing powers of carbonic oxide and cyanogen.

Carbonic acid and cyanogen, carefully prepared and dried, were introduced in measured quantities into a mercurial gas-holder. The specimens of oxide of iron were exposed in porcelain tubes to a current of the mixed gases, all air having been previously expelled. Heat was applied by means of a Hofmann's gas-furnace, and the temperature of the interior of the tube was ascertained by means of the electric pyrometer of Dr. Siemens, which during the experiment did not indicate a greater fluctuation than 25° C.

I formerly ascertained that when equal volumes of carbonic oxide and carbonic acid were passed over peroxide of iron at a red heat, it was impossible to remove oxygen below that required to form protoxide of the metal; and in like manner,

when metallic iron in the form of sponge was similarly treated, it was transformed into porous oxide. In neither case was any deposited carbon produced.

In the present trials, the proportions of cyanogen and carbonic acid first employed were one volume of the former and six of the latter, because in such a mixture the relation of oxygen to carbon is the same as that subsisting in equal volumes of the two gaseous oxides of carbon which, as just stated, were incapable of reducing iron to the metallic state.

Experiment 1.—Such a mixture (1 of Cy+6 of CO_2) was passed through the tube containing no oxide of iron at a temperature of 814° C., which was gradually lowered. The gas as it escaped was so nearly absorbed by potash as to be accounted for by a trace of atmospheric air remaining in the apparatus; for the slight trace of unabsorbed gas burnt with the characteristic blue flame of carbonic oxide. It was therefore inferred that heat alone effected no change in this mixture of the two gases.

Experiment 2.—A similar mixture (1 Cy+6 CO_2) was passed over pure peroxide of iron at a temperature varying from 685° to 711° C. Large quantities of nitrogen and carbonic oxide were given off during the whole of the experiment, accompanied by cyanogen and carbonic acid escaping unchanged.

The original weight of the ferric oxide was	1·6465	gramme.
After an exposure of 13 minutes, during which 1·28 litre of the mixed gases had passed through the tube, it weighed	1·5295	,,
After a lapse of $2\frac{3}{4}$ hours, and after 8·5 litres of the gases had passed, it weighed	1·5855	,,

On analysis the substance exposed was found to consist, for every 100 parts of iron, of—

Iron in the metallic state	56·3
Iron as an oxide	43·7
Oxygen	9·1
Carbon	28·5

In this case 79·9 per cent. of the original oxygen has been removed.

Experiment 3.—Spongy iron was now exposed to the same mixture (1 Cy+6 CO_2) at a temperature of 712° to 726° C. The issuing gases contained carbonic oxide and nitrogen, as in the previous experiment.

The original iron weighed	1·314	gramme.
In 56 min. 6·7 litres of the mixed gases had passed through the tube, the iron was found to weigh	1·596	,,
In 2 hrs. 20 min. 14 litres had been used, and the product weighed	1·600	,,

For every 100 parts of iron it consisted of—

Iron in the metallic state	58·7
Iron as an oxide	41·3
Oxygen	9·6
Carbon	12·2

There is such a similarity in the composition of the products in experiments 2 and 3 as to render it probable that at the same temperature, when about 57 or 58 per cent. of the iron exists as metal, and the remainder consists of 8 equivalents of iron united to 6 equivalents of oxygen, further action ceases, whether iron or its peroxide be the substance employed.

The superior power of cyanogen over carbonic oxide to keep in check the oxidizing tendency of carbonic acid having been demonstrated, the latter was now increased in quantity.

Experiment 4.—Pure peroxide of iron was exposed to a current of 1 volume cyanogen and 15 volumes of carbonic acid, the temperature varying from 801° to 811° C.

The issuing gases again contained, as before, nitrogen and carbonic oxide.

The oxide employed weighed	1·6700	gramme.
In 1·5 hr. 8·2 litres of gas had passed over, when the substance weighed	1·5955	„
In 2·5 hrs. 16·5 litres of the gases had gone over, and it weighed	1·561	„

For every 100 parts of iron it consisted of—

Iron in the metallic state	6·5
Iron as an oxide	93·4
Oxygen	32·2
Carbon	1·3

Experiment 5.—Spongy iron was similarly exposed.

The original metal weighed	1·1340	gramme.
After 1·5 hr. exposure to 7·7 litres of gases it weighed	1·5015	„
After 2·5 do. 17 „ „	1·5635	„

After which for every 100 parts of iron it consisted of—

Iron in the metallic state	4·3
Iron as an oxide	95·7
Associated with oxygen	33·1
Carbon	4·7

In these last two experiments the oxygen and iron exist in proportion of 6 equivalents to 5; and having regard to the circumstances of the trials, it appears probable that a position of static equilibrium has been reached.

The quantity of carbonic acid was then doubled, *i. e.* for each volume of cyanogen 30 volumes of carbonic acid were made use of.

Experiment 6.—Pure peroxide of iron heated to 770°–780° C. was exposed to such a mixture (1 vol. Cy + 30 vols. CO_2).

Weight of peroxide of iron employed	1·0615	gramme.
After 2 hrs. exposure to 8 litres of gases it weighed	·9915	„
After 3 „ „ „	1·0130	„

For every 100 parts of iron the product consisted of—

Iron in the metallic state	·90
Iron as an oxide	99·10
Associated with oxygen	33·82
Carbon	2·52

Here, again, 6 equivalents of oxygen are combined with 5 of iron, but the metal in its free state is diminished in quantity. The small difference in weight between the ends of the second and third hour indicates here the probable absence of further change.

The next series of experiments was performed in a Griffin's blast-furnace at a temperature at which cast iron is fused.

Experiment 7 proved that a mixture of 1 volume cyanogen and 6 of carbonic acid were unaltered by mere exposure to this degree of heat.

Experiment 8.—When the two gases in these proportions, 1 vol. Cy + 6 vols. CO_2, were passed over peroxide of iron, the amount of nitrogen and carbonic oxide was very trifling. On examination it was found the ferric oxide had fused with the substance of the porcelain, and thus it might have interfered with the action. A trace of carbon was detected, probably deposited as the apparatus cooled.

Experiment 9.—The temperature was lowered, but with the same results as in Experiment 8.

Experiment 10.—Further reduction in the temperature, but still no definite result was obtained.

Experiment 11.—Recourse was again had to Hofmann's furnace, and a bright red heat employed something under fusing-point of silver.

14·4 litres of the mixture, 1 vol. Cy+6 vols. CO_2, during 3 hrs. 10 min. were passed over pure peroxide of iron, after which for every 100 of iron it was found to consist of—

Iron in the metallic state	22·7
Iron as an oxide	77·3
Associated with oxygen	17·4
Carbon	13·8

Experiment 12.—Pure peroxide of iron was exposed during a period of 2 hrs. 50 min. at a similar temperature to that of the previous experiment; but the gas (16 litres) consisted of 1 volume of cyanogen to 15 volumes of carbonic acid, and for every 100 of iron the product consisted of—

Iron in the metallic state	0·0
Iron as an oxide	100·0
Oxygen	28·9
Carbon	0·5

In this case the iron is almost precisely associated with the necessary oxygen to form protoxide.

In all these experiments cyanogen has been employed in its uncombined state, whereas in the blast-furnace this substance is almost entirely united with potassium or sodium. The difficulty, if not indeed the impossibility, of adjusting known proportions of a vaporized cyanide and carbonic acid induced me to use the cyanogen in the manner described. I did not hesitate to adopt this mode of procedure, because I almost invariably found the quantity of cyanogen, when compared with the potassium and sodium in the gases, indicated the decomposition of this compound of carbon and nitrogen during their progress through the heated contents of the blast-furnace.

In eight trials, at an aperture 8 feet above the level of the tuyeres, the average quantities per cubic metre of gas were found to be—

Potassium	24·73	grammes.
Sodium	4·38	"
Cyanogen	15·06	"

whereas at the point of exit of the gases, about 65 feet higher up in the furnace, there was only found in an average of five trials:—

Potassium	7·04	grammes.
Sodium	2·03	"
Cyanogen	3·77	"

In the first case 100 parts of the metals are accompanied by 51·7 per cent. of cyanogen, whereas in the second this is reduced to 41·5 per cent. The diminution in the potassium and sodium themselves is, of course, due to their condensation among the cooler contents of the furnace; and it is in this way that the great accumulation of these cyanides and other alkaline salts can be accounted for, and which in one case amounted per cubic metre of gas to:—

Potassium	73·47	grammes.
Sodium	39·23	"
Cyanogen	49·06	"

It would of course be rash, in the absence of actual examination of the gases of one of these Austrian furnaces, to ascribe their superior action to the use of charcoal instead of coke. All, therefore, that this paper can pretend to is an indication of the direction in which the cause of the difference may lie; for it seems clear that oxygen may be present in much larger proportions in a mixture of cyanogen and carbonic acid than in one of carbonic oxide and carbonic acid, and a strong reducing and carbon-depositing tendency still retained. Possibly also the mere facts as they are here described may not be considered devoid of scientific interest.

In conclusion, I would remark that it is only when white iron is the object sought for, that this unusual economy of fuel is apparent in Austria. This, I have

imagined, may be due either to the more rapid decomposition or more speedy evaporation and expulsion of the cyanogen compound from the furnace at the higher temperature which is known to prevail in the hearth when manufacturing grey iron.

On the Dissociation of Nitric Acid by various means. *By* P. Braham, *F.C.S., and* J. W. Gatehouse.

The first series of the following experiments was performed by passing the vapour of nitric acid of sp. gr. 1·48 through tubes exposed to various temperatures, it being found that the higher the temperature to which the vapour was exposed the greater was the percentage of HNO_3 decomposed, and also that the dissociation which occurred at high temperatures was more complete than that which took place at lower temperatures.

By passing nitric-acid vapour through molten tin, 2·51 per cent. of the vapour issuing from the retort was decomposed, and 0·7 per cent. of gas evolved. This gas contained 95 per cent. of oxygen, the remainder, after explosion with hydrogen, being nitrogen.

By passing the vapour through molten lead from 21·28 to 31·84 per cent. was dissociated, and from 2·96 to 4·1 per cent. of gas evolved.

The vapour being heated by means of a Bunsen's burner, 54·09 per cent. was decomposed and 8·05 per cent. of gas evolved.

The heat from a charcoal fire, the vapour being conducted through a hard glass tube, decomposed about 65 per cent. of acid * and yielded 10·44 per cent. of gas. With a charcoal fire, the vapour being passed through a porcelain tube, 89·7 per cent. was decomposed and 13·23 per cent. of gas evolved.

In the second series, conducted by passing nitric acid through a clay pipe exposed to various temperatures, that of a T-shaped Bunsen decomposed 71·72 per cent., yielding 9·13 per cent. of gas.

Using a clay pipe heated with charcoal, 83·4 per cent. suffered decomposition, yielding 11·5 per cent. of gas.

In these two series of experiments the percentage of oxygen contained in the gas collected gradually decreased from 95 per cent. in the case of molten tin to 78·4 per cent. in the case of the charcoal fire, the remainder consisting of nitrogen and nitrous oxide. Nitrous acid or tetroxide of nitrogen was produced largely in every case, but was absorbed and estimated separately.

The proportions of O, N, and N_2O could not be determined with exactitude; but in the case of the T-shaped Bunsen the amount approximated to 79·6 per cent. of O, 10 of N_2O, and 10·4 of N.

It thus appears that the whole of the oxides of nitrogen are produced during the dissociation of nitric acid by heat; an approximation to the reactions occurring may be expressed by the following formula:—

$$8HNO_3 = 4H_2O + 2NO_2 + N_2O_3 + N_2O + N_2 + O_{12}.$$

Experiments were also undertaken by us to ascertain whether any decomposition of nitric acid occurred during the act of boiling.

Pure nitric acid is not decomposed; but if it contains nitrous acid, then decomposition proceeds till the whole of the N_2O_3 is expelled, when no further change ensues.

The decomposing action of sunlight on nitric and nitrous acids was also studied.

Pure nitric acid placed in a full bulb, sealed, and exposed several days to sunlight, remained colourless, and without evolution of gas; but the same acid exposed to sunlight in a sealed tube only partially full was powerfully decomposed, yielding over 1 per cent. of nitrous acid and a considerable amount of gas.

This action in sealed tubes is not continuous; for when the nitrous acid formed attains to about 2 per cent. of the quantity of nitric acid present, all decomposition ceases.

* The amount could not be accurately determined, as the heat fused the glass tube, and a little of the acid was lost.

This dissociation by sunlight is due to the violet end of the spectrum, the red end having no effect whatever.

Liquid nitrous acid, obtained by condensing the gas derived from the action of arsenious acid on nitric acid and exposing it in a strong sealed tube, is not decomposed.

On a Mode of producing Spectra on a Screen with the Oxyhydrogen Flame. By P. BRAHAM, *F.C.S.*

On the Mode of writing Chemical Equations. By Professor CRUM BROWN, *F.R.S.E.*

On Methyl-thetine. By* Prof. CRUM BROWN *and* Dr. E. A. LETTS.

On the Replacement of Organic Matter by Siliceous Deposits in the Process of Fossilization. By Dr. W. B. CARPENTER, *F.R.S.*

The Injurious Effects of Dew-rotting Flax in certain cases. By WILLIAM CHARLEY, *J.P., of Seymour Hill, near Belfast.*

The cultivation of the flax-plant in the field is not a matter of extraordinary difficulty. It is the after-management that generally embarrasses the farmer, and particularly in those districts where the crop is tried for the first time. The extension of flax-cultivation in the British Isles would be very useful to the important industry of the linen manufacture, and would add a remunerative crop to the limited list of the British agriculturist. At present the land occupied by flax is chiefly to be found in Ulster. The present year's return gives 102,789 acres for this province, the rest of Ireland showing only 4097 acres. The author is not aware of any accurate statistics on the subject regarding England and Scotland, but a few thousands would probably cover the quantity of acres cultivated.

The first difficulty that meets the inexperienced farmer after his flax is gathered off the field is the steeping-process. The celebrated Louis Crommelin (appointed overseer of the linen manufacture in Ireland by King William III.), writing in 1705 on the subject of preparing flax, quaintly says:—"Flax may be prepared without watering by grassing it until such time as the stem corrupts; yet it is better to water it where it can possibly be done without great inconvenience."

So far as the author can form an opinion, this plan of preparing without watering, commonly called "dew-rotting," is quite unsuited for any but the coarsest flax, such as would not be spun into yarn used for making bleaching cloth. There is something in the process of steeping flax (a process more accurately, perhaps, described by the common expression of retting or rotting) which seems necessary to ensure the attainment of high colour when the prepared fibre is manufactured into cloth, and arrives at the bleaching department. The fermentation, which seems to be of a putrefactive nature, acts on the juices and gummy matters which cement the woody stem to the pure fibre of the plant, and also not only assists the after separation of these, which is the object of the subsequent scutching-operation, but has such a powerful effect on the colouring-matter of the fibre as to render the change required in bleaching much more safe and successful. But though grassing alone is not sufficient to make a proper preparation of good fibre, it is, after the steeping is over, a most useful and necessary addition.

There is another point worth mentioning in connexion with the steeping of flax; brackish water, such as may be met with in the low-lying districts near the sea, should be carefully avoided. The practice of using it is now generally admitted to be injurious to the fibre intended for white linen; it also gives a leaden dull colour

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in many cases to the flax itself. With respect to improvements in the flax-steeping process, there is really very little to report of late years. The ordinary open-air system is carried on in much the same way as when Louis Crommelin wrote in 1705. Various new plans have been suggested, and to some extent practised with more or less success.

The author described several of these new plans, and concluded by saying:—"The time may arrive when a regular and extensive business may be taken up in all flax-growing districts by enterprising individuals with the object of buying the flax from the farmers in the green state, and treating it in an improved way on a large scale, combining probably the steeping of the flax and scutching-operations in the same establishment. Meantime let farmers who wish to make a profit in growing flax attend as carefully to the watering process as to the field cultivation, and avoid as a general rule the imperfect dew-rotting system, or the use of brackish water in any of the pools intended for steeping this valuable plant."

On the General Equations of Chemical Decomposition. *By* Professor CLIFFORD, *F.R.S.*

On the Composition of certain Kinds of Food. *By* W. J. COOPER.

On Spontaneous Generation from a Chemical Point of View. *By* Professor DEBUS, *F.R.S.*

On an Aspirator. *By* Professor DELFFS.

On the Latent Heat of Liquefied Gases. *By* Dr. DEWAR, *F.R.S.E.*

On Chlorine, Hypochlorous Acid, &c., and Peroxide of Hydrogen. *By* THOMAS FAIRLEY, *F.C.S.*

It is shown that under certain circumstances chlorine and hydrogen peroxide react so as to give hypochlorous acid: thus

$$Cl_2+H_2O_2=2HClO.$$

A large excess of chlorine must be used, and the peroxide containing 2·45 per cent. added gradually to the chlorine-water. The peroxide is acted on, and the chromic-acid test does not show its presence in the mixture. On further addition of peroxide much gas is given off, which is pure oxygen.

If we stop the addition of peroxide while there is still large excess of chlorine, and cautiously add ferrous sulphate solution to remove the excess, a bleaching liquid is obtained having the characteristic smell and properties of hypochlorous acid.

The evolution of oxygen arises from a secondary reaction of hypochlorous acid and hydrogen peroxide.

$$HClO+H_2O_2=HCl+H_2O+O_2.$$

The oxygen is given off equally from the hypochlorous acid and the peroxide. Besides hypochlorous acid I have verified this equation with calcium, sodium, and potassium hypochlorites. Brodie has shown that a similar reaction takes place with barium peroxide and solution of bleaching-powder in acetic acid. The reaction of hypochlorous acid and peroxide of hydrogen explains the evolution of oxygen in continued addition of the peroxide to chlorine-water, or its immediate evolution on addition of chlorine-water to peroxide.

Bromine and iodine give similar results. Their solutions in dilute alkali also evolve oxygen with the peroxide.

In the case of iodine and peroxide the hydriodic acid formed is also acted on by the peroxide, so that the amount of iodine at the end of the reaction, when all the peroxide is decomposed, is the same as at first. A small amount of free iodine can, therefore, even in cold dilute solutions, decompose an unlimited quantity of peroxide. If an alkaline iodide or free alkali be present, then the more stable iodide is not so readily decomposed by the peroxide.

The author reserves the discussion of hypotheses until he has completed experiments with other oxygen acids of chlorine and sulphur.

On Perchloric Acid. *By* T. Fairley, *F.C.S.*

When ozone is passed into a solution of hypochlorous acid or hypochlorite, perchloric acid is formed, probably thus—

$$HClO+O_3=HClO_4.$$

Ozonized air passed through a solution of sodium hypochlorite gives a liquid which, in neutral solutions, precipitates potassium from its compounds as potassium perchlorate. The author is continuing his experiments to prove that the complete molecule of ozone is absorbed as such with a view to explaining the constitution of perchloric acid.

The author has proved that hydrogen peroxide (2·45 per cent.) does not react on chloric acid or chlorates to give perchloric acid, and that no action of any kind takes place. The peroxide has no action on perchloric acid and its salts, which in this respect differ from the permanganates. The above-mentioned experiment is the first of its kind involving the formation of perchloric acid at ordinary temperatures.

Electrolytic Experiments on some Metallic Chlorides. *By* Professor Gladstone *and* Alfred Tribe.

During experiments on their air-battery the authors observed that if plates of copper and platinum be immersed in a solution of chloride of copper and be metallically connected, cuprous chloride is deposited on the platinum plate, while the copper plate is also attacked, and a galvanic current passes through the liquid from the metal of higher to that of lower potential. Weak external currents produce a similar electrolysis of $Cu\,Cl_2$ into $Cu\,Cl$ and Cl between platinum poles. Combinations of zinc or magnesium with platinum decompose cupric chloride still more energetically, with the production of some metallic copper as well as cuprous chloride on the negative plate. Precisely analogous experiments were obtained with mercury and gold immersed in mercuric chloride, the insoluble mercurous salt being deposited on the gold plate.

On the Petrified Wood of Lough Neagh. *By* Professor Hodges, *M.D., F.C.S.*

The occurrence along the shores of Lough Neagh, in Ireland, of masses of petrified wood has from very early times attracted attention, and many ancient writers, and several modern authorities, have ascribed to the waters of this lake remarkable petrifying qualities.

Bischof, in his 'Chemical Geology,' also refers to the property of the water of petrifying wood placed in it, or rather causing its impregnation with iron, which induced him, he says, to make a chemical analysis of it. He, however, merely examined the insoluble portion of the matters left on evaporating the water, and found, contrary to what he had expected, that there was an extraordinary small quantity of earthy constituents. From the suspended matter, by means of hydrochloric acid, he extracted iron and alumina, but in too small a quantity to admit of estimation. The fact that peroxide of iron, he remarks, is the chief constituent of the suspended matter, is in accordance with the statement, in the Philosophical

Transactions, that the lapidifying substance is iron, and that, when the petrification is only partial, upon burning such a wood only the petrified part comes to a glow heat, and the ash which is left is attracted by the magnet. Bischof also made a partial examination of a specimen of the petrified wood, which, however, does not sustain his views respecting the ferruginous nature of the lapidifying material, as he found it to contain only 0·54 per cent. of oxide of iron and alumina.

The specimen of petrified wood examined by Bischof gave the following results:—

Silica	97·71
Oxide of iron and alumina	0·53
Loss on ignition	0·54
Loss and organic matter	1·22
	100·00

On ignition only a feeble empyreumatic odour was perceptible and a slight darkening in colour.

Immense masses of the petrified wood have been found along the shores of the lake. Some of the pieces of wood discovered are of large size; and one mass, described by Dr. Barton in his lectures in Natural Philosophy, &c., published in Dublin in 1751, weighed so much as 700 lbs.; and there is at present, or was lately, at Langford Lodge, near Crumlin, in the county of Antrim, a silicified trunk, ten feet long and about the same in circumference. The specimens discovered vary very much in hardness and in colour: when associated with lignites, they are easily split, and dark-coloured; but when occurring as boulders in the drift, they are bleached on the surface white, the interior is black or dark brown. On the surface of some of the specimens minute crystals of quartz are found. The woody structure of the petrifactions is in general well marked, and microscopic examination shows it to be that of coniferous trees. By Kraus it has been named *Cupressoxylon Pritchardi*, which among living Coniferæ is represented by Cupressaceæ and Podocarpeæ.

The author on several occasions submitted the water of Lough Neagh to chemical examination, and also made analyses of specimens of the silicified wood. These analyses show that in no part of the lake does the water contain any considerable amount of solid matter, and that neither in the water nor in the petrified wood is to be found more than a very minute quantity of iron. A specimen of the water which had been taken at Sandy Bay, 100 yards from the shore and four miles from Glenavy river, near a part of the lake shore in which the petrified wood is frequently discovered, when received was slightly turbid from finely divided flocculent matter, and the colour, when viewed through a layer two feet in length, was pale greyish yellow. Its taste was soft, and a considerable number of animalcules were moving about in it. It had an alkaline reaction.

On evaporation it left a yellowish-coloured residue, which became black on ignition.

An imperial gallon contained 12·950 grains, consisting of:—

Mineral and saline matters	10·826 grains.
Organic and volatile	2·124 „

The mineral matters were found to consist of:—

	grains.
Carbonate of lime	4·786
Carbonate of magnesia	0·496
Carbonate of soda	1·038
Sulphate of soda	1·715
Oxide of iron	0·727
Silicic acid	0·360
Chloride of sodium	1·704
	10·826

The author also determined the amount of mineral matter contained in the water at two other portions of the lake. A specimen taken at the mouth of the river Bann, which, rising from springs in the granitic range of the mountains of Mourne,

after a course of about thirty miles, falls into Lough Neagh, and, passing through it, issues as the Lower Bann at the north end of the lake, was found to yield 13·4 grains of solids, of which 10·6 grains consisted of mineral matters; while in another locality, about half a mile from the shore, the mineral matters were only 9·3 grains per gallon.

The water of the Upper Bann, except when it has been rendered impure by the numerous bleaching and other works on its banks, contains a very small amount of mineral matters. A gallon on one occasion was found to contain only 4·614 grains of mineral matters, consisting of:—

	grains.
Carbonate of lime	1·239
Sulphate of lime	1·354
Carbonate of magnesia	0·622
Oxide of iron	0·329
Silicic acid	0·245
Chloride of sodium	0·825
	4·614

A specimen of the petrified wood weighing 26 ounces, in which the woody structure was clearly visible, and which was white on the outer surface and of a dark brown colour in the interior, when exposed to a strong heat in the crucible became black, and evolved an odour somewhat resembling that of burning wood, and by continuing the heat, left a pale buff-coloured residue. Contrary to what is stated by some authorities, the wood was not affected by the magnet before or after ignition. In no specimen has the author found the ash magnetic.

100 parts of the specimen yield as follows:—

Loss on ignition and organic matter	6·50
Alumina soluble in hydrochloric acid	0·68
Oxide of iron	0·04
Lime	0·29
Magnesia	0·25
Phosphoric acid	trace
Alumina in state of silicate	1·95
Lime	1·10
Magnesia	0·25
Silicic acid	89·01
	100·07

In another specimen from a different locality the loss on ignition was 9·1 per cent. It contained 84·5 per cent. of silica and only 1·5 per cent. of oxide of iron and alumina.

The analyses, therefore, show that the water of Lough Neagh, in our time at least, possesses no peculiar qualities, and that the lapidifying material of the petrified wood is silicic acid and not oxide of iron.

The examination of the specimens also clearly shows that the hardening is not produced merely by superficial incrustation of the lapidifying silicic acid, but that it has penetrated through almost every portion of the vegetable structure.

On the Composition of Tea and Tea-Soils from Cachar. *By* Professor Hodges, *M.D., F.C.S.*

Notwithstanding the important place occupied by the tea-plant in the dietary of so large a portion of the world, its chemical examination has attracted comparatively but little attention. We owe to Peligot and Mulder the most valuable investigations which have been made in connexion with it; and more recently we have been supplied with some analyses of the ash of teas from the laboratory of Professor Horsford, while Wanklyn and Allen have lately contributed many facts of great

value in reference to the examination of the tea of commerce and the detection of adulteration.

Some time ago Professor Zöller read before the Physico-Medical Society of Erlangen a paper on the chemical investigation of a Himalaya tea (Repertorium für Pharmacie, Band xx. Heft 8), which possessed peculiar value, from the circumstance that the specimen examined might be regarded as consisting of genuine tea without any foreign admixture, having been received from the growers by the late Baron von Liebig. Professor Zöller's investigations confirmed the correctness of observations which he had formerly made respecting the influence which the age of the leaves of plants exercised on the composition of the ash—that while young leaves are found to be rich in potash and phosphoric acid, and poor in lime and silica, the amount of lime and silica in the ash increases with the age of the plant. As the best qualities of tea are known to consist (as will be shown below) merely of the very young shoots of the plant, the estimation of the amount of potash, phosphoric acid, lime, and silica may be usefully, as he suggested, employed in enabling us to judge of the quality of a specimen of tea.

The richness of the tea-ash in potash and phosphoric acid, showing that the tea had been prepared from young leaves, suggested that the amount of matters in the leaves soluble in water, and of nitrogen, and also probably of theine, would be large. These anticipations were confirmed by the investigations. The extract obtained by treating the leaves with boiling water weighed 36·38 per cent., and the nitrogen 5·38 per cent., while the theine amounted to 4·95 per cent. of the air-dried leaves.

Some time ago the author had an opportunity of submitting to examination specimens of tea grown in Cachar, under the superintendence of Samuel Davidson, Esq., and also a specimen of fine Cachar tea forwarded to him from the same district by Dr. Joseph Nelson. Mr. Davidson's specimens were taken from the fields in August, and were carefully enclosed in tinfoil, and may therefore be regarded as representing genuine, unmixed specimens of Indian tea. Mr. Davidson also kindly supplied the following history of the crop from which the specimens were taken:—"The leaves were taken from plants in their seventh season, and consisted of the young shoots from which tea is manufactured, viz. the bud, and first, second, and third leaves down the stem. In none of the samples were there old leaves or actual wood. A shoot with this number of leaves is usually the growth of about twelve days after the bud has got started to grow. The indigenous sample is from the variety of the plant which was originally found growing wild in the jungles of these districts. The author thinks that it is the true *Thea viridis*. It is a very large-growing plant, almost a tree, and its leaves when full-grown are very large and succulent. It yields by far the best quality of tea. The other sample was from a hybrid plant. This is supposed to be a true hybrid between the indigenous and China varieties, and certainly partakes very much of the peculiarities of both varieties. The China plant is the variety, which is probably the correct *Thea Bohea* originally imported direct from China. It is a miserable, small-growing, stunted plant compared to the indigenous, the full-grown leaves being only about 2 inches long, and the tea is inferior. The hybrid gives a good strong tea, and is a hardier plant than the indigenous, and so is very much liked, but the more closely it approaches to the indigenous it is the more highly prized." The specimens received by the author had been merely dried in heated rooms. The produce of the crop was estimated at 400 lbs. of dried tea per English acre. It is so seldom that we are able to obtain any precise account of the history of the specimens of tea and other foreign productions which have been submitted to chemical examination, that Mr. Davidson's report possesses especial importance.

100 parts of each variety of the tea gave the following results:—

	Indigenous.	Hybrid.
Moisture	16·06	16·20
Organic matters	78·81	78·98
Mineral matters	5·13	4·82
	100·00	100·00
Nitrogen in the dried tea	4·74	2·81

The ash of each respectively consisted of:—

	Indigenous.	Hybrid.
Potash	35·200	37·010
Soda	4·328	14·435
Chlorine	3·513	2·620
Sulphuric acid	5·040	6·322
Phosphoric acid	18·030	9·180
Oxide of iron	2·493	2·463
Protoxide of manganese	1·024	0·800
Lime	8·986	5·530
Magnesia	4·396	5·910
Sand and silica	0·500	1·300
Charcoal	2·900	1·830
Carbonic acid	13·590	12·600
	100·000	100·000

The author was also enabled to submit to examination specimens of the soil and subsoil from the fields on which the tea had been grown. Both soils were of a reddish colour and in fine powder, the subsoil, which was taken 1 foot 6 inches below the surface, being rather deeper in colour than the soil. A textural examination of the specimens was made according to the method as described in the author's work on 'Chemistry for Farmers,' and gave the following result:—

100 parts of each respectively were found to consist of—

	Soil.	Subsoil.
Sand in fine powder	71·5	82·5
Clay	28·5	17·5

Carbonate of lime, less than 5 per cent.

Both soils may therefore be described as sandy loams.

Chemical Composition.

100 parts of each respectively consisted of:—

	Soil.	Subsoil.
Organic matters	4·75	5·18
Chloride of sodium	0·11	0·35
Potash	0·03	0·03
Oxide of iron	6·00	7·20
Oxide of manganese	trace	trace
Alumina	2·02	3·86
Lime	trace	0·10
Magnesia	0·12	0·05
Sulphuric acid	0·07	0·35
Phosphoric acid	0·05	0·03
Insoluble siliceous matters	64·80	56·50
Moisture	22·20	24·44
Nitrogen per cent.	0·158	0·22

The amount of nitrogen and alkalies in the subsoil, it will be perceived, exceeds that which was found in the surface-soil. This may be owing to the circumstance that heavy rains (40 inches within four months) had fallen for some time before the specimens were taken.

Another sample of Cachar tea, kindly forwarded to the author by Dr. Joseph Nelson, was also examined, chiefly for the purpose of ascertaining how far we could rely upon the determination of the amount of matters which are removed by heating tea with boiling water, as indicative of the presence in the tea of commerce of exhausted tea or of foreign leaves.

100 parts of the specimen were found to contain 4·963 parts of moisture, and the ash amounted to 5 parts. By treating the leaves with boiling water until exhausted of soluble matters, and evaporating the solution to dryness, an exact weighing (42·4

grains) was obtained. Determinations of the amount of nitrogen in the leaves as received, and also in the insoluble residue, were made; and while the nitrogen of the original sample amounted to 4·425 per cent., the insoluble residue was found to contain only 2·109 parts, the amount of mineral matters by treatment with water being reduced to 1·56 part; so that 68 per cent. of the total mineral matter of the tea, and about 58 per cent. of the nitrogen, had been removed in the infusion.

On the Composition of the Fibre of the Jute-plant, and its use as a Textile Material. By Professor HODGES, *M.D., F.C.S.*

At the Meeting of the Association held in Belfast twenty-two years ago, the author read a report on the composition of the flax-plant, the fibre of which supplies the raw material of the staple industry of this part of Ireland. In that and subsequent reports he gave an account of a series of investigations which had been undertaken at the request of the Association, and in which the composition of the fibre and the changes which it undergoes in its technical preparation were for the first time completely examined. The interest which these reports excited in this great centre of the linen industry, has encouraged him to offer some account of the history and chemical composition of another textile material, which at the time of our former Meeting was scarcely known in this country, but which has lately assumed a most important place among the vegetable substances employed by manufacturers. Fifty years ago the fibre of the jute-plant was to be found only in our museums, now the quantity of it introduced into the United Kingdom almost equals that of the flax which we import, and exceeds the annual importation of hemp; and owing to the improvements which have been effected in the processes for its preparation, and especially in the methods of bleaching, it is, the author believes, destined to occupy in future a far more important place among the raw material of our textile manufactures. The plant which yields the fibre known in commerce as jute (a name which is supposed to be derived from a corruption of the Bengali name of the plant) is a member of the family Tiliaceæ, the Linden or Lime-tree family, which from remote periods has been cultivated by the natives of Southern Asia for textile purposes. Two species of it are used for the production of fibre, *Corchorus capsularis* and *Corchorus olitorius*, and both kinds are found in the jute brought to this country. The *Corchorus* is an annual, the seeds of which are sown broad-cast in the months of March and April on ploughed land along the sandy banks of rivers, usually neither irrigation nor manure being required. In August, before the seeds which replace the small yellow flowers of the plant have ripened, and when the stems have attained the height of about 12 feet, the crop is cut: when the seed is allowed to become fully ripe, as is also the case with flax, the fibre becomes stiff and hard, and the stem is rendered of a reddish colour. The stalks when cut are tied in bundles and placed in tanks, usually of dirty water, and allowed to ferment, or "ret," for five or six days, and then taken out and swung about repeatedly in the air, by which the long fibres are separated from the brittle wood which constituted the bark of the stem; and thus prepared, the fibres are dried by exposure on the ground to the air, and, when dry, packed in round bundles for the market. The treatment of the plant for the separation of the fibre is therefore precisely like the ordinary methods used by farmers in this country in the preparation of the flax-fibre. The produce of jute far exceeds that of flax, being, it is stated, five times as great as that which flax affords. Though India is the great seat of jute cultivation and supplies the fibre used in this country, yet the jute-plants, especially *Corchorus olitorius*, have been long cultivated in China and other eastern countries. Experiments have been made to grow the plants for textile purposes in the Southern States of America, on the banks of the Lower Mississippi, and also in Algiers, and it is said the results are encouraging.

For some time after the introduction of jute, the opinion prevailed that it could not be bleached, and was therefore of little value as a textile material. Experiments made at several times proved that this was a mistake; but until lately scarcely any progress had been made in improving the qualities of the fibre, or giving it the whiteness of linen fabrics. The difficulties, however, which retarded

the success of jute-bleaching have, during the present year, been completely removed, by the application of methods which have been invented by the son of the author, and which are at present in operation. In the processes employed, the cloth or yarn, by means of ingeniously arranged machinery, is made to pass in succession through baths of alkaline solutions and hypochlorites of magnesia and soda, the magnesia used being economically obtained from kieserite, which is found in large quantities in Germany in the kainite deposits, and has hitherto been regarded as of but little commercial value.

The length of the fibre of the jute of commerce is frequently no less than 12 feet; usually the lower end near the ground is dark-coloured and woody. At first the fibre is colourless, or only slightly coloured; but some kinds after a time become darker, just as wood darkens in colour by the action of the air. Many specimens preserve a dull yellowish colour, and in appearance can with difficulty be distinguished from the finer qualities of hemp. The microscope, however, shows us that the structure of the jute is different from that of any of our common textile fibres; thus, while a fibre stripped from the flax-plant is shown to consist of bundles of cells with thick walls and somewhat circular outline, and exhibiting a very minute central space, the wall of the jute-cell is of very irregular thickness, and the central space does not conform to the external outline, but at one part will be found wide, while at another part it dwindles to a mere line. By this remarkable difference in the contour of the inner and outer cell-walls, jute-fibre is distinguished from flax, hemp, cotton, and New-Zealand flax. The application of the sulphate of aniline proposed as a reagent for woody matter by Runge, and recommended by Professor Wiesner, of Vienna, also affords us assistance in distinguishing it from both hemp- and flax-fibres. Thus, while hemp is scarcely at all affected by this action of the reagent, and flax unchanged in colour, the jute-fibre shows that it contains a large amount of woody matter by becoming of a deep golden-yellow colour. The sulphate, however, does not enable us to distinguish jute from several other Indian fibres.

In connexion with the technical preparation, bleaching, &c. of the jute-fibre, the author lately commenced a series of investigations which, though not so far advanced as he had hoped, may not be destitute of interest. The samples of fibre submitted to examination were of the kind known as "Red Seraigunge." The fibre had a faint red colour, and measured in length 10 feet 9 inches. It had been prepared in the ordinary manner, and of course contained only those constituents of the plant which remained attached to the cellular structures after being subjected to the process of retting. Portions of the fibre cut into small pieces, after being treated with distilled water and boiled for several hours, gave an acid solution of the colour of pale ale, which evolved an odour which suggested the aromatic smell of moist flax-yarn. On evaporation over the water-bath, it left a brownish-black extract, which in appearance resembled black-currant jelly; it was translucent at the edges, and was easily reduced to a light brown powder. This extract amounted to only 0·726 per cent. of the fibre, and was found to contain sugar and a tannic acid which gave an olive-green precipitate with persalts of iron, a fatty substance, and a brown-red colouring-matter. The extract was in part soluble in alcohol, and heated on platinum it carbonized without melting, leaving a white ash. It contained no starch. The fibre employed, dried at 212°, was found to contain 15·5 per cent. of moisture, and when incinerated to leave 1·329 per cent. of ash of a pale yellowish-white colour, treated by the successive action of solvents, according to the methods described in the author's reports on flax*, and the amount of nitrogen determined by Wills's method, both in the original samples and in the fibre after the action of the solvents. The results obtained were as follows:—

One hundred parts yield—

Moisture	15·540
Organic matter	83·131
Mineral matters	1·329
	100·000

* Reports of British Association, 1852 and 1853.

One hundred parts of the fibre dried at 212° yield—

Wax and fatty matters soluble in ether	0·235
Tannic acid and colouring-matters soluble in alcohol	1·135
Sugar, pectine, &c.	2·427
Soluble nitrogenized matters	0·512
Insoluble nitrogenized matters	2·433
Inorganic matters united with the fibre	1·010
Cellular fibre	92·248
	100·000
Nitrogen in the original fibre	0·291
Nitrogen in the fibre after treatment with solvents	0·210

The author had hoped to be able to give an analysis of the jute-plant in the condition in which it is removed from the field; but unfortunately a specimen which had been forwarded from Calcutta arrived only a few days ago, and he must therefore defer its investigation until some other opportunity. With respect to the magnitude of the jute manufacture, the author stated that in the present year one hundred thousand tons of the fibre were imported into Dundee alone, by direct shipment from Calcutta, while London, Liverpool, and Glasgow received probably half as much more. The rapidity with which, by means of improved machinery, it can be manufactured, may be judged from the fact, that since the opening of the Suez Canal the fibre has been delivered in Dundee, spun and woven, and the goods shipped back and paid for, within six months from the date of the bill of lading. At the present time jute is used for the manufacture of a great variety of fabrics. In fact it will serve for the production of every kind of coarse textile material. It is even used as a substitute for hair, and can be formed into admirable chignons. The dust from the mills is employed to make silk hats, and the waste fibre yields an excellent pulp for the manufacture of paper. Stair-carpets of jute, with bright colours, can be sold at three pence per yard; and woven into what are known as carpet bed-covers, a fabric is produced at not more than one third the price of wool.

*On an Improved Vacuum Filter-pump**. *By* W. Jesse Lovett.

The advantages claimed for this pump are its practical efficiency and portability, and also its non-liability to get out of order.

It consists of a metallic cone provided with a convex metallic cover; to the apex of the cone is fitted a tube for carrying away waste water; and in the middle of the convex cover is fixed a tube which goes down nearly to the apex of the cone; and at this end is fixed a jet formed by soldering a square pyramid of brass in the end; the pyramid has a hole through its centre which points straight down the exit-tube. The square pyramid being fixed in a round tube leaves four orifices for the water to pass through, thus forming a rude rose-jet; and the centre hole serves as a jet to drive the air caught by these four orifices straight down the waste-pipe. The upper tube being connected with a good force of water, the rose exhausts air from the cone and drives it down the waste-pipe. One of Professor Thorpe's admirable valves is fitted to the convex cover, and a tube connected with this is fixed to the filter as required.

The average results obtained with this as a filter-pump are:—

The time of filtration is reduced to about one sixth on the average.

The pump supports, as a rule, 15 or 16 inches of mercury; this of course varies with the fall of water obtainable; with a good fall of water results as high as 20 inches have been attained.

The apparatus may be used as an aspirator for drawing a current of air through the apparatus. It may also be used as a water-blowpipe, by attaching the waste-pipe to one of the holes of a three-bored cork; into the other holes are fixed a tube going to the blowpipe and a tube with adjustable orifice for carrying away waste water. The extreme length of the pump described is $6\frac{1}{2}$ inches.

* *Vide* 'Chemical News,' May 15, 1874.

On the Estimation of Phosphoric Acid as Pyrophosphate of Magnesia. *By* T. R. OGILVIE.

On a Sesquisulphide of Iron. *By* Dr. T. L. PHIPSON, *F.C.S.*

This is a substance of a beautiful dark emerald-green colour, having the composition $Fe^2 Cl^3$, which is produced when ferric chloride is added to a solution of ammonia sulphide containing a considerable amount of hypochlorite of soda, or whenever a persalt of iron containing free chlorine or a hypochlorite is precipitated by sulphide of ammonium.

It forms a dark green flocculent precipitate, appearing quite black when collected and washed. Its fine green colour becomes apparent when, after drying, it is ground up with a perfectly white powder such as chalk.

Its properties are rather remarkable. It is soluble to a notable extent in water containing ammonia, and separates therefrom as the ammonia escapes; it is even soluble in alcoholic ammonia, forming in each case a bright emerald-green solution. It is only slightly soluble in a mixture of sulphide and hypochlorite rather diluted; neither is it more than slightly soluble in either of these alone. It is more easily dissolved in hot water containing free ammonia.

In hydrochloric acid it dissolves with great effervescence, immediately producing perchloride of iron, $Fe^2 Cl^3$, in spite of the abundance of sulphuretted hydrogen present.

On analysis it is proved to be a hydrated sesquisulphide of iron, answering very nearly to the formula $2Fe^2 S^3+3HO$.

On the Presence of Cyanogen in Commercial Bromine, and a means of detecting it. *By* Dr. T. L. PHIPSON, *F.C.S.*

The author has lately discovered a notable amount of cyanogen in samples of bromine supposed to be pure and issued as such for pharmaceutical purposes. It has been long known that during the manufacture of iodine a certain quantity of that beautiful but dangerous compound *iodide of cyanogen* sometimes finds its way into one of the glass condensers; and from the fact just alluded to it would appear that a similar compound with bromine may occasionally be produced during the manufacture of this liquid element; this is a more serious case than the other, since the impurity is dissolved and hidden in the liquid.

The presence of cyanogen in bromine may be detected by taking an equal weight of iron filings to that of the bromine to be examined, adding to them four or five times their weight of water and mixing in the bromine gradually, stirring all the time. The liquid must be filtered while warm from the reaction, and the filtrate allowed to stand in a partially closed bottle; in the course of about twenty-four hours a precipitate of ferricyanide of iron (Berlin blue) will have formed, and may be collected on a filter.

If *perfectly pure* bromine were used this reaction would also enable us to detect cyanogen in steel, and to decide whether or no it is ever present in that metal.

Notes on the Preparation of the Sulphur-urea. *By* Prof. EMERSON REYNOLDS.

On the Action of the Sulphur-urea in Metallic Solutions. *By* Professor EMERSON REYNOLDS.

On a Self-registering Apparatus for Measuring the Chemical Action of Light. *By* Professor ROSCOE, *F.R.S.*

On certain Abnormal Chlorides. By Professor Roscoe, *F.R.S.*

On the Chlor-Bromides and Brom-Iodides of the Olefines. By Professor Maxwell Simpson, *F.R.S.*

On the Specific Volumes of certain Liquids. By Professor Thorpe.

On some Opium Derivatives. By Dr. C. R. Wright.

GEOLOGY.

Address by Professor Edward Hull, *M.A., F.R.S., F.G.S., President of the Section.*

Following the example of several Presidents of the Geological Section of the British Association, I purpose commencing our proceedings by an address, selecting for my subject the volcanic phenomena of the district in which we are assembled. But before entering upon this subject, I am sure it will be equally in accordance with your feelings and my own if I give expression to the general and deep regret which is felt at the death (so little expected) of the late President of this Section, Professor John Phillips, of Oxford, on the 24th of April last, in the 74th year of his age.

The late Professor Phillips.—As the nephew and pupil of Mr. William Smith, "the Father of English Geology," Professor Phillips was nurtured in an atmosphere of geological science which accorded well with his own tastes; and in his youth was the companion and assistant of his uncle in many a surveying-tour in the east and north of England. His subsequent appointment as Keeper of the Museum at York, and one of the Secretaries of the Yorkshire Philosophical Society, gave him opportunities and scope for pursuing his inquiries—ultimately resulting in the publication of his laborious work on 'The Geology of Yorkshire,' a work not only abounding in local details, but containing the germs of several generalizations on questions relating to physical geology.

Of his connexion with the Geological Survey of Great Britain, Professor Phillips has left two enduring monuments in his work on 'The Palæozoic Fossils of Cornwall, Devon, and West Somerset,' and that on 'The Malvern Hills and surrounding districts'*—one dealing with the organic structures, and the other more especially with the physical conditions of the south and west of England.

To his future career as Professor of Geology in the University of Dublin, afterwards, on the death of Dr. Buckland, in the University of Oxford, or as President of the Geological Society of London in 1859 and of the British Association at Birmingham in 1865, it is unnecessary for me in this brief notice to do more than allude. Through these years and down to the time of his decease his fertile brain and ready pen were ever at work. But the scope of his investigations was not limited to purely geological subjects; he was a man of many parts, and astronomical questions largely engaged his attention in his later years. In 1868 he visited Italy and Vesuvius, and subsequently published a little work on the history and structure of that mountain in a form very acceptable to that large portion of the

* "The Malvern Hills compared with the Palæozoic Districts of Abberley, Woolhope, May Hill, Tortworth, and Usk," Mem. Geol. Survey, 1849.

travelling British public which at one time or another makes the delightful pilgrimage to the workshop of Vulcan and the Phlegræan Fields.

The loss of Professor Phillips's presence at the meetings of the British Association, of which he was one of the founders, is irreparable. His genial face and lucid words brought sunshine wherever he appeared, and threw light on every topic he handled; to him might well be applied the words—"quidquid tetigit ornavit." While lamenting his loss, let us endeavour to imitate the example of his untiring industry, his patient pursuit of the beautiful and noble in Nature, his honesty of character, his purity of life*.

The Volcanic District of the North-east of Ireland.—I have now to direct your attention to the district of County Antrim and its neighbourhood as one claiming our special investigation, and presenting a multitude of interesting problems connected with the volcanic phenomena of the Tertiary period. By the labours of Berger, Weaver, Portlock, Griffith, Bryce, Tate, Holden, and other geologists many of these problems have received a solution; others remain for further discussion. It shall be my endeavour to give you a brief summary of the facts and inferences arrived at up to this time, and to present you with a connected history of the operations carried on by terrestrial agents in this island, from the commencement of the volcanic era to its close.

This era, though short as compared with the sum of geologic time, was in reality vastly extended, and comprised within its limits several stages or divisions characterized by special physical conditions. Speaking in geological terms, it probably included the latter part of the Eocene and the whole of the Miocene periods, interrupted by long pauses in the outburst of volcanic products.

But before entering upon the narrative of events which occupied this space of time, let us first endeavour to determine the physical limits of the theatre of these operations; for it may well be asked, considering the great extent to which the volcanic products have been cleared from off the surface of the country by denudation, with what degree of precision can we define the original limits of the volcanic area?

Let us for a moment, when replying to this question, turn to a still more recent volcanic district for an illustration. When we ascend the cone of Vesuvius, and from that commanding station sweep with our eyes the surrounding region, we find ourselves in the centre of a plain—the Campagna of Naples—formed of the products of volcanic eruptions, but limited through three quarters of a circle by calcareous hills of older date, and along the other portion by the sea.

I believe that similarly, but on a far more extended scale, we can trace out the original limits of the volcanic district of the north-east of Ireland, and that from some elevated stations rising from the central plateau of Antrim these limits may be almost descried by the uprising of ridges of more ancient rocks in several directions. Taking our stand on Tardree Hill, or Sleamish, we see to the southward the granitic and schistose ridge of Slieve Croob, projected against a background of the mountains of Mourne, culminating in Slieve Donard. Westward the eye rests on the rugged masses of Slieve Gullion and the Silurian hills of Newtown Hamilton. Towards the north, after passing the depression of the southern shore of Lough Neagh and the valley of the river Blackwater, the enclosing ridge of old rocks, forming from this distance an apparently unbroken line, ranges northward into Donegal and the northern shores of Lough Foyle. The ocean now intervenes; but a comparison of the physical characters of the Donegal mountains with those of Islay, Jura, Cantyre, and the Western Highlands leaves the impression on my mind that the volcanic region of Antrim was limited northwards along the line of a submarine ridge, and that there is little reason for supposing that the volcanic rocks of Mull were superficially connected with those of this country,—on the contrary, the probability seems to be that the old crystalline rocks of the Western Highlands were interposed between the two regions.

Turning to the eastward, the sea overflows an area at one time occupied by volcanic products, but now only partially so, and we are unable strictly to define

* An interesting memoir of the late Professor Phillips will be found in the 'Geological Magazine,' vol. vii. p. 301 (1870).

their easterly limits; but it is tolerably certain that the sheets of lava did not reach the shores of Galloway or those of the Isle of Man. Basaltic dykes, however, as is well known, traverse the north of England and the south of Scotland; but if referable, as Professor Geikie concludes, to the Miocene period, they cannot be included in the volcanic region as here described and understood.

Thus the volcanic plateau of Antrim, like the Campagna of Naples, is washed on one side by the sea, and its limits become indefinable in consequence; but to the south, the west, and to some extent to the north, the limits of the region are marked out by mountains of considerable elevation. Within this region craters poured forth lavas or other volcanic products, which extended in great sheets until they were intercepted by the uprising of these natural barriers.

The floor of the area thus partially circumscribed was formed of various materials, as the accidents of denudation admitted. Over the central portions it was chiefly Cretaceous limestone (or Chalk), but to the southward it was New Red Sandstone and Lower Silurian, and to the north, Chalk, Lias, Carboniferous, and Lower Silurian beds in different directions. The whole region composed of rocks thus distributed was probably converted into dry land towards the close of the Eocene period—when, at various points, highly silicated felspathic lavas burst forth, consolidating into sheets of trachyte porphyry, rhyolite, and more rarely pitchstone, such as are found at Brown Dod Hill and Tardree, near Antrim, and west of Hillsborough. These trachytic lavas were therefore the oldest of the volcanic eruptions of the north of Ireland, and seem to have been represented by the newer granitoid rocks recently described by Zirkel, Geikie, and Judd in the Island of Mull on the one hand, and by the trachytes of Mont Dore in Central France on the other. They have been described in this district by Berger and Bryce; but it is only recently that their relations to the other lavas have been clearly determined; and as such rocks are exceedingly rare in the British Isles, I trust the Members of the Association will take this opportunity of paying a visit to the quarries near Antrim, where they are fully opened to view. In composition, both at Hillsborough and at Antrim, they present a felspathic base, enclosing crystals of sanidine (or glassy felspar) and grains of quartz. At Brown Dod Hill they are disposed in sheets, showing lines of viscous flow and dipping beneath the overlying beds of basalt.

As I have already stated, the outpouring of these trachytic lavas may, with every probability, be referred back to the later Eocene period. At any rate, a considerable interval probably elapsed before the eruption of the next series of lavas of Miocene age, which are essentially augitic, and may be comprehended under the heads of basalt and dolerite with their amygdaloidal varieties. Sheets of these lavas were formed, from various vents, over the uneven surface of the older rocks, and to a far greater extent, both as to area and thickness, than in the case of the preceding eruptions of trachyte *. These beds, which are often vesicular, attain in some places a thickness of 600 feet, and are surmounted by decomposed lava and volcanic ashes, which mark the close of the second period of eruption.

The sheets of augitic lava which were poured forth during this stage are remarkable for their vesicular character and the numerous thin bands of red ochre (bole or laterite) which separate the different lava-flows, and which have been recognized by Sir C. Lyell as probably ancient soils formed by the decomposition of the beds of lava, similar to those in Madeira and the Canary Islands, resulting from streams of subaërial origin. Microscopic examination bears out this view; for a thin slice of one of the more compact beds of bole from the north coast showed that the felspar-prisms retained their form, while the augite and magnetite ingredients had passed into the state of an ochreous paste.

The vesicular and amygdaloidal character of these older beds of lava shows the probability that they have been poured forth under no greater pressure than that of the atmosphere, and together with the evidence derived from the bands of ochre leads to the conclusion that they have been erupted over land-surfaces. Some of

* In this respect they resemble the corresponding rocks in Central France, where, as Mr. Scrope has shown, the trachytes have a more restricted range than the basalts ('Volcanoes of Central France').

the vents of eruption are now visible, either in the form of amorphous masses of trap protruded through the sheets, or of great funnels filled by bombs, broken pieces of rock, and ashes, such as the rock on which is perched the venerable ruin of Dunluce Castle (the ancient stronghold of the MacDonnells), or the neck erupted through the Chalk in the coast-cliffs near Portrush *. One of these old funnels was found by the late Mr. Du Noyer near this place: it forms a portion of the crest of the ridge overlooking Belfast Lough, to the east of Cave Hill, and is within easy reach of Members of the Association.

The period of the formation of the older sheets appears to have been brought to a close by the discharge of volcanic ashes and the formation of an extensive lake, or series of lakes, over the region extending at least from the shores of Belfast Lough to the northern coast of Antrim, in which the remarkable beds of pisolitic iron-ore were ultimately deposited. This is the only mode of origin of these ores which seems to me at all probable; and I am consequently unable to accept the views advanced by Messrs. Tate and Holden regarding their origin from basaltic lava by a process of metamorphism. That water was present, and that the beds of ash which underlie the pisolitic ore were stratified, at least in some instances, is abundantly evident upon an examination of the sections at Ballypalidy, Ballymena, and the northern coast. In some places they are seen to be perfectly laminated in a manner that could only take place by the agency of water †. It would seem, therefore, that by the combination of slight terrestrial movements a shallow basin was formed over the area indicated, which received the streams charged with iron in solution, draining the upland margins, from the waters of which were precipitated the iron, possibly by the agency of confervoid algæ, as in the case of the Swedish lakes of the present day (a view maintained by Mr. D. Forbes, F.R.S.), or by the escape of carbonic acid, owing to which the iron became oxidized and was precipitated.

Upon these uplands grew the plants whose remains occur amongst the ash-beds of Ballypalidy, the Causeway, and elsewhere, and which have enabled Mr. Baily to refer the strata in which they occur to the Miocene period ‡. In some places the vegetation crept over the surface of the former lake-bottom as it became shallower or was drying up, and gave rise to beds of lignite similar to those described by the Duke of Argyll as occurring at intervals amongst the basalts of Mull §. The beds of ore, wherever they are found, belong to one and the same geological horizon, and enable us to separate the basaltic series into two great divisions—one below, and the other above the position of the pisolitic ore; and which, on maps of the Geological Survey, will for the future be represented by two different shades of colouring.

The ore itself is now laid open in numerous adits driven into the hill-sides, or in open works at Island Magee, Shane's Hill, Broughshane, Red Bay, Portfad, and other places ‖, whence it is transported to the furnaces of Scotland, Cumberland, Lancashire, and Wales. A new source of industry and wealth is rapidly springing up over the already prosperous county of Antrim, and ere many years are over we may expect to see furnaces established at several points for smelting the ores at the mines from which they are extracted.

The period of volcanic inaction just described was brought to a close by fresh eruptions of augitic lavas, which spread in massive sheets over the beds of ore, bole, and even lignite, without materially altering their constitution. Thus on the

* A sketch of this old rock is given by Professor Geikie in Jukes's 'Manual of Geology,' 3rd edit. p. 271.

† The authors referred to, while admitting the stratified character of the beds at Ballypalidy and their formation in presence of water, consider that in all other cases the iron-ore has been formed on a terrestrial surface; but sections seen at Ballymena and the north coast have led me to conclude that these beds are all more or less stratified, and due to aqueous deposition.

‡ Quart. Journ. Geol. Soc. vol. xxv. p. 357, pls. 14 & 15. The plants determined by Mr. Baily, from Ballypalidy, belong to the genera *Sequoia, Cupressites, Rhamnus, Quercus, Pinus,* &c. They were originally detected by the late Mr. Du Noyer.

§ Jukes's 'Manual of Geology,' 3rd edit. p. 690.

‖ At Pleaskin Head it was originally observed by the Rev. Dr. Hamilton (1790).

north coast a band of lignite is interposed between the pisolitic ore below and a massive bed of columnar basalt above, which can be followed and identified by the size and regularity of its columns for several square miles over that district. That this molten rock has not utterly reduced the lignite to ashes, or even entirely obliterated the impressions of the plant-remains, has been doubtless due to the rapidity with which a hard crust, of low conducting-power, consolidates on the outside of a lava-stream, as has been frequently observed on Vesuvius and other active volcanoes.

Above this peculiarly massive bed were piled fresh sheets of basalt and dolerite to a total depth of at least 400 feet, each flow of lava being consolidated in a somewhat different manner from those above and below it, and probably separated from them by considerable intervals of time, as bands of ochre intervene in most instances between successive beds indicating subaerial soils of decomposed lava.

The maximum thickness of the basaltic sheets of Antrim has been estimated by Mr. Duffin and myself at 1100 feet, to which must be added perhaps 200 feet for the subordinate trachytic beds, giving a total of 1300 feet for the whole volcanic series. This is rather more than originally assigned by Dr. Berger, who places it at 900 feet*, but it falls far short of the enormous accumulations of Mull, estimated by Professor Geikie at from 3000 to 4000 feet; in neither district, however, have we the data for determining the original thickness of volcanic *ejecta*, as in both large masses of material have been wasted away by denudation, and not a single volcanic cone or crater remains behind out of all those which, probably in numbers corresponding to those of Central France, were planted over the entire volcanic region.

The basaltic dykes, which traverse not only the geological formations subordinate to the bedded traps, but also the latter themselves, are, in some districts, both remarkable and exceedingly numerous. To the south of Belfast Lough we find at Scrabo Hill an outlying mass of bedded dolerite resting on New Red Sandstone, and far beyond the limits of the main masses which rise in a fine escarpment to the north of the Lough. There is every probability that Scrabo Hill is the site of a distinct focus of eruption; but it is also remarkable for the dykes of trap, as well as intrusive sheets, which have been squeezed in between the beds of sandstone themselves. Admirable and instructive sections are laid open in the freestone-quarries of this hill, which will amply repay a visit. Another district remarkable for such intrusions is that of Ballycastle, where dykes and sheets are seen traversing the Carboniferous rocks, as described by Sir R. Griffith in his admirable Report on the geology of that coal-field†; while the well-known Giants' Causeway is itself a tessellated pavement of columnar basalt, traversing in the form of a dyke the horizontal sheets of older formation.

The intrusion of the thousands of dykes of the north-east of Ireland is unaccompanied by crumplings or contortions of the strata; and if it were possible to place the dykes side by side, their aggregate breadth would cover a space several thousand feet in breadth. How, then, has this additional space amongst strata of given horizontal dimensions been obtained? Has it been by lateral tension outwards owing to inflation by means of elastic gases or vapours, or by a general bulging of the surface consequent on lateral pressure? The former view, I am told by physicists, is untenable; the latter is one which will probably prove more consonant with modern views of terrestrial dynamics.

The results of the microscopic examination of a considerable number of specimens of augitic lavas from various parts of the volcanic district are of a generally uniform character. Whether we take specimens from the largely crystalline granular dolerites of Portrush or Fair Head, or the very dense micro-crystalline basalts of Shane's Castle, the structure and composition is found to be nearly uniform.

The lava is, with very few exceptions, an amorphous or subcrystalline paste of augite, enclosing long prisms or plates of labradorite felspar, crystalline grains of titano-ferrite, and often of olivine. Chlorite is also sometimes present as a "secondary" mineral. It will be observed that this diagnosis differs essentially

* Trans. Geol. Soc. 1st series, vol. iii.

† 'Geological and Mining Survey of the Coal-districts of Tyrone and Antrim' (1829). Some of the sheets in this district may be of older date than the Miocene age.

from that assigned by Dr. Zirkel as the normal structure of basalt, in which the base is "a glass," and the other minerals (the augite, felspar, and olivine) are individually crystallized out*. This, indeed, is the case with the Carboniferous melaphyres of the south of Ireland†, and probably with all the rocks in which augite is deficient; but the basalts of Antrim contain augite so largely in excess of the felspar that it has, in nearly every case, formed the base of the rock‡.

The basalt itself is often so rich in iron as to become an impure iron-ore. This is owing to the presence of the metal in the form of minute grains of titaniferous iron-ore, which is the principal cause of the black appearance of the rock, and also as one of the components of the augite.

From the above general review of the volcanic history of Tertiary times in the north of Ireland it will be evident that it presents us with three distinct periods, similar to those which Mr. Judd has recognized in the succession of events in the Island of Mull:—

The earliest, possibly extending as far back as the later Eocene period, characterized by the trachytic lavas.

The middle, referable to the Miocene period, characterized by vesicular augitic lavas, tuffs, and plant-beds.

The latest, referable to a still later stage of the Miocene period, characterized by more solid sheets of basalt and numerous vertical dykes.

These three stages were probably separated from each other by long intervals of repose and the cessation of volcanic action. The succeeding Pliocene period seems to have been characterized by considerable terrestrial movements, resulting in the production of fractures in the earth's crust, and (as my colleague, Mr. Hardman, supposes) in the formation of that large depression which was filled with waters having a greater area than the Lough Neagh of the present day. Some of the faults which traverse the upper sheets of basalt, and are therefore of later date, have vertical dislocation amounting to 500 or 600 feet, as, for instance, that which runs along the valley under Shane's Hill near Larne. Such great fractures must necessarily have been accompanied by denudation, and it is probable that many of the present physical features had their origin at this (Pliocene) period. The extent to which the original plateau of volcanic rocks has been broken up and carried away within such comparatively recent times is vaster than is generally supposed. As there is evidence that the sheets of lava to the north of Belfast Lough were originally connected with those of Scrabo Hill to the south, we must suppose that this arm of the sea and the valley of the Lagan have been excavated since the Miocene period; while on the north-west the high elevation to which the escarpment of the basalt reaches, leads to the supposition that the basaltic sheets spread over the ground now occupied by Lough Foyle. Both along the west and along the eastern seabord the sheets of lava are abruptly truncated, and must have extended far beyond their present bounds; while many deep valleys, such as those of Glenarm, Cushendall, and Red Bay, have been excavated.

But the most remarkable result of the denudation, as bearing upon the subject before us, is the complete obliteration of the volcanic cones which we may well suppose studded the plateau. Some of these cones, at least, were contemporaneous with those now standing upon the granitic plateau of Central France, and which are but little altered in elevation since the fires which once burst forth from them became extinct. But since then the north of Ireland has been subjected to vicissitudes from which Central France has been exempted. The surface of the country has been overspread by the great ice-sheet of the earliest stage of the Glacial period, which appears to have stretched across from the Argyleshire Highlands, if we are to judge by the direction of the glacial *striæ* at Fair Head§.

* 'Untersuchungen über d. mikrosk. Zusammensetzung und Structur der Basaltgesteine' (1870).

† E. Hull, "On the Microscopic Structure of the Limerick Carboniferous Melaphyres," Journ. Roy. Geol. Soc. Ireland, vol. iii. p. 112 (with plates).

‡ Mr. Allport, F.G.S., states (Geol. Mag. 1873) that he has found the augite individually crystallized out in a specimen from near the Causeway. Such a case, however, must be exceptional; but the rule as stated above certainly holds good.

§ A view also held by Mr. James Geikie and Mr. Campbell of Islay.

At a later stage the country was submerged beneath the waters of the Interglacial sea, which deposited the sands and gravels which overlie the Lower Boulder-clay; and subsequent emergences during the stage of the Upper Boulder-clay, together with atmospheric agencies constantly at work whenever land has been exposed, have moulded the surface into the form we now behold.

It will thus be seen that the physical geologist, whether a Vulcanist or a Neptunist, has in this region abundant materials on which to concentrate his attention.

Volcanic Energy.—In connexion with this subject, it may not unnaturally be expected that I should make some allusion to the views of Mr. Robert Mallet on "Volcanic Energy," which he has recently unfolded in the 'Philosophical Transactions of the Royal Society'*. My limits, however, forbid more than a cursory glance at this subject. Stated in a few words, volcanic energy, according to Mr. Mallet, has its origin primarily in the contraction of the earth's crust, due to secular cooling and the tendency of the interior molten matter to fall inwards and thus leave the exterior solid shell unsupported. The lateral pressure arising therefrom (which, as Mr. Mallet shows, is vastly greater than the vertical weight of the crust) is expended in crushing portions of the solid crust together, along lines of fracture which are supposed to correspond to those of the volcanic cones which are distributed over the earth's surface. Each successive crush produces an earthquake-shock, and is converted into heat sufficient to melt the rocks which line the walls of the fissure or lie beneath at high temperatures, and which, in presence of elastic steam and gases, are erupted at intervals both of time and place.

In the words of the author of these views:—"The secular cooling of the globe is always going on, though in a very slowly descending ratio. Contraction is therefore constantly providing a store of energy to be expended in crushing parts of the crust, and through that providing for the volcanic heat. But the crushing itself does not take place with uniformity; it necessarily acts *per saltum* after accumulated pressure has reached the necessary amount at a given point, where some of the unequally pressed mass gives way, and is succeeded perhaps by a time of repose or by the transfer of the crushing action elsewhere to some weaker point."

It cannot be denied that Mr. Mallet's theory seems to be consistent with many observed facts connected with volcanic action. It has for its foundation an incontestable physical hypothesis, the secular cooling of the earth, and it seems to throw considerable light upon several observed phenomena of volcanic action—such as the distribution of cones and craters along great lines, the intermittent character of eruptions, and the connexion of earthquake-shocks with volcanic outbursts. There are some statements in Mr. Mallet's paper which few physical geologists will be inclined to accept, such as the non-existence of true volcanoes before the Secondary or Mesozoic period. The Silurian volcanic districts of North Wales and of the west of Ireland, and the Carboniferous volcanic districts of Limerick and Scotland, bear witness against the soundness of such a view. This statement, however, does not necessarily invalidate the general views of the author; and I cannot but think that the publication of Mr. Mallet's paper has enabled us to take a very long stride in the direction of a true theory of volcanic energy.

Further Researches on Eozoon Canadense. *By* W. B. Carpenter, *F.R.S.*

On the Fossils of the Posttertiary Deposits of Ireland. By the Rev. John Grainger, *D.D.*

At the last Belfast Meeting in 1852 the author gave a list of the shells found in the alluvial deposits of Belfast. To the 'Natural-History Review,' vol. vi., for

* 1873, vol. clxiii. p. 147.

1859, he contributed an account of all that had been obtained up to that date. Mr. S. A. Stewart subsequently published a list of the fossils of the estuarine clays of the counties of Down and Antrim, in which further progress was recorded with great accuracy. At the Brighton Meeting in 1872 Professor Edward Hull gave lists of shells found in the raised beaches of Balbriggan, Kilroot, and Larne, in the identification of which he had been assisted by Mr. W. H. Baily, F.G.S. In the 'Geological Magazine,' October 1873, Mr. Alfred Bell, writing on the Palæontology of the Postglacial Drifts of Ireland, brings into one memoir many details scattered throughout various scientific journals bearing on Irish Posttertiary Geology. In the 'Geological Magazine' for May of this year (1874), the Rev. M. Close contributed a paper on the elevated shell-bearing gravels near Dublin, giving lists of shells found at elevations of 1000 feet and upwards. Mr. Kinahan and Mr. Hardman have also written papers bearing on the subject—the former in the 'Geological Magazine,' March and April of this year, and the latter in the 'Journal of the Royal Geological Society of Ireland.'

The author purposed on the present occasion to contribute the names of species which had occurred in such localities as he had himself examined.

These localities are the following:—

(1) Dungiven, co. Derry; (2) Ballyrudder, co. Antrim; (3) Balbriggan, co. Dublin; (4) Howth, co. Dublin; (5) Ballybrack, co. Dublin; (6) Larne Curran, co. Antrim; and (7) Portrush, co. Antrim.

(1) At the Dungiven Quaternary bed, which rises to the height of 400 feet above the level of the sea, he had got the following species:—

Cardium edule.
Cyprina Islandica.
Astarte sulcata.
Astarte borealis.
Corbula gibba.
Turritella terebra.

(2) From a bed of stratified gravel in the townland of Ballyrudder, on the westward side of the road and halfway between Larne and Glenarm, Dr. Jeffreys obtained a most interesting lot of Posttertiary fossils. They occurred at about 15 feet above high water. They were as follow:—

Rhynchonella psittacea.
Mytilus edulis; fragments.
Leda pernula; in distinct layers.
Astarte sulcata, var. elliptica.
—— compressa.
Tellina balthica.
—— calcaria.
Mactra solida, var. elliptica.
—— subtruncata.
Pholas crispata; fragments.
Turritella erosa.
Natica Montacuti.
—— affinis.
Buccinum undatum, var. undulatum.
Trophon clathratus.
Pleurotoma turricula, var.
—— Woodiana.
—— Pingelii.
Balanus tulipa-alba.

To these the author had been enabled to add the following:—

Cardium, sp.
Cyprina Islandica.
Astarte borealis.
—— depressa, *Brown*.
Mya truncata.
Saxicava rugosa.
Puncturella noachina.
Trochus cinerarius.
Littorina obtusata.
—— rudis.
—— litorea.
Purpura lapillus.
Trophon truncatus.
Cliona borings.
Annelid borings.
Mammoth-tooth, exhibited.

The last item is particularly interesting, inasmuch as it throws light on a discovery recorded by the 'Clonmel Chronicle' in the following terms:—"*Extraordinary Discovery.*—A few days since, as Benjamin Fayle, Esq., of Merlin, was walking with his sons on the bye-road leading from Glenhackett to the lower road near Kilgany, one of the lads picked up what appeared to be a curious stone, but what is in reality the tooth of a Siberian fossil elephant in an excellent state of preservation. Some weeks since there was a terrible mountain-flood produced by heavy rain, and the supposition is the tooth may have been washed down from the

hills. The road on which it was lying was greatly cut up, and this relic of antiquity was lying among the débris."

During the year 1869, when workmen were removing gravel for ballast from the Curran at Larne, the upper part of the thigh-bone of a mammoth was found along with some fragments of a whale about 20 feet below the surface of the Curran, which is itself there about that height above high water.

(3) At Balbriggan, where the sea undermines and breaks away the land on the Skerries side, the author found the following species disclosed between 10 and 40 feet above the sea-level:—

Nucula, sp.	Corbula gibba.
Leda abyssicola.	Saxicava Norvegica.
—— pernula.	—— rugosa.
—— arctica.	Dentalium entalis.
Pectunculus glycymeris.	Patella vulgata.
Cardium echinatum.	Littorina rudis.
Cyprina Islandica.	Turritella terebra.
Astarte sulcata.	Buccinum undatum.
—— borealis.	Nassa incrassata.
Isocardia cor.	Pleurotoma turricula.
Tellina balthica.	Balanus sulcatus.
—— calcaria.	
Solen siliqua.	

(4) The following species were observed by him at Howth in the cutting for a new road on the hill above the town, about 100 feet above the sea:—

Ostrea edulis.	Mya truncata.
Pecten opercularis.	Pholas crispata.
Leda pernula.	Patella vulgata.
Cardium echinatum.	Littorina litorea.
—— edule.	Turritella terebra.
Cyprina Islandica.	Buccinum undatum.
Astarte sulcata.	Fusus antiquus.
—— borealis.	—— Islandicus.
—— depressa.	Pleurotoma turricula.
Mactra solida, var. elliptica.	Balanus sulcatus.
Tellina balthica.	Annelid borings.

(5) The following were obtained by him at Ballybrack, near Killiney, imbedded at heights between 10 and 20 feet above high water:—

Ostrea edulis.	Mya arenaria.
Cardium edule.	Trochus cinerarius.
Astarte borealis.	Turritella terebra.
—— compressa.	Fusus antiquus.
Venus verrucosa.	Cypræa Europæa.
—— exoleta.	Balanus sulcatus.
Tellina balthica.	

(6) From the railway-cutting through the Curran, Larne, the author obtained the following at heights varying from 10 to 20 feet above high water:—

Anomia ephippium.	Trochus cinerarius.
Ostrea edulis.	—— zizyphinus.
Pecten varius.	Littorina obtusata.
Cardium edule.	—— rudis.
Kellia suborbicularis.	—— litorea.
Lucina borealis.	Turritella terebra.
Tapes pullastra.	Cerithium reticulatum.
Tellina tenuis.	Purpura lapillus.
Corbula gibba.	Buccinum undatum.
Saxicava rugosa.	Nassa reticulata.
Helcyon pellucidum.	—— pygmæa.
Patella vulgata.	Cliona borings.
Trochus magus.	

Professor Hull's list of the fossils of Kilroot corresponds with the author's list of shells of the raised beach beyond Carrickfergus (the same district) given at the close of the author's paper in the 'Natural-History Review' for 1859.

(7) The following is a list of the species obtained by the author in the Portrush bed discovered by Col. Portlock, height 10 feet above the sea:—

Anomia ephippium.
—— ——, var. aculeata.
—— pectiniformis.
Ostrea edulis.
Pecten pusio.
—— varius.
Mytilus edulis.
Arca tetragona.
Nucula nucleus, bored by Natica.
Cyprina Islandica.
Venus casina.
—— fasciata.
—— ovata.
Tapes pullastra.
Mactra subtruncata.
Mya Binghami.
Saxicava rugosa.
Patella vulgata.
Helcyon pellucidum.
Fissurella Græca.
Trochus cinerarius.
—— zizyphinus.
Phasianella pulla; operculum.
Lacuna divaricata.
—— puteolus.
Littorina obtusata.
—— rudis.
Littorina litorea.
—— neritoides.
Rissoa parva.
—— striata.
—— semistriata.
—— cingillus.
—— cancellata.
——, sp.
Hydrobia ulvæ.
Odostomia unidentata.
Natica Montacuti.
Cerithium reticulatum.
Cerithiopsis tubercularis.
Triforis perversa.
Purpura lapillus.
Buccinum undatum.
Murex erinaceus.
Nassa reticulata.
—— incrassata.
Defrancia linearis.
Pleurotoma costata.
Cypræa Europæa.
Salicornaria farciminoides.
Cliona borings.
Echinus sphæra.
Caryophyllia Smithii.
Cancer pagurus.

Specimens of nearly all the species enumerated in the paper are preserved in the author's cabinet, and have been submitted to the kind scrutiny of Mr. Gwyn Jeffreys.

On some new Localities for Upper Boulder-clay in Ireland. By Edward T. Hardman, *F.C.S., F.R.G.S.I., of the Geological Survey of Ireland.*

In Mr. James Geikie's valuable work on the 'Great Ice-Age,' as well as in a former memoir by him on "Changes of Climate during the Glacial Epoch"*, the presence of an Upper Boulder-clay in this country is hardly admitted, save in the north-eastern portion, where it is (somewhat doubtfully) allowed to exist. The author now proposed to mention some new localities where he had observed it.

In various parts of the counties Armagh, Derry, and Tyrone the three divisions of the drift are met with, viz. 1. Upper Boulder-clay; 2. Stratified Sand and Gravel (Middle Sands); 3. Lower Boulder-clay †; but the Upper Boulder-clay can rarely be identified with certainty, except when it rests on the summits of very high drift hills, or where sufficiently deep cuttings are found to expose the underlying sands. In the neighbourhood of Dungannon, the drift being extremely hilly, the whole three members can be found in places; and a section was exhibited and explained, showing the Upper Boulder-clay resting on the Middle Sands, at Castle Hill, Dungannon, Killymeal Quarry, and Gortmerron. The Upper Boulder-clay was also observed in the Ulster Railway-cuttings at Coolhill and Coolcush, at Windmill Hill, south, and Mullaghdun, north of Dungannon, in the vicinity of Stewartstown, and in the co. Derry in the low ground to the north of Slieve Gallion.

* Geological Magazine, vols. viii. & ix.
† Following the classification of Prof. Hull and Prof. Harkness.

In the more central parts of Ireland, especially in the Queen's County, Carlow, and Kilkenny, the drift also admits of a tripartite arrangement, and in general character closely resembles that of the north; but the whole is often loosely described as "limestone gravel"*. In many places the Upper Boulder-clay is found reposing on a greatly denuded surface of stratified and sometimes current-bedded sand and gravels, or even on the Lower Boulder-clay, as at Coonbeg, Queen's County, south-west of Athy. In the same stream (the river Douglas), one mile to the west, the whole three members are found superimposed.

At various places near the town of Carlow, as at the railway bridge and at Erindale House, the Upper Boulder-clay is found resting on denuded and current-bedded gravels.

At Archersgrove, near Kilkenny, thick Boulder-clay rests on coarse gravels, while a mile to the south the Upper Boulder-clay lies directly on the limestone rock †.

Besides the places named, a great part of these counties is covered with a very peculiar Boulder-clay which is inferred to be the upper, although the base is rarely seen. It consists of a confused mass of round *water-worn* pebbles or paving-stones, chiefly limestone, from 30–40 per cent., in some cases being well and deeply *scratched on the rounded surface.* These are huddled together in an *unstratified* matrix of sandy clay. It cannot be a Lower Boulder-clay, for the pebbles are rounded by water action. It could not be relegated to the Middle Sand or Esker Series, for the pebbles are well scratched. It can therefore only be Upper Boulder-clay. Where Upper Boulder-clay is found resting on the gravels, it contains at the base quantities of these rounded and scratched pebbles.

All these characteristics agree perfectly with its being an Upper Boulder-clay. The glaciers which gave rise to the upper clays must have passed in many places over the already rounded and stratified gravels with which this part of the country was covered, and would of course remove a great deal of them. This detritus becoming mingled together with clay and pieces of unrounded rock from places uncovered by drift, would result in a confused mass of pebbles, clay, sand, and boulders, and would naturally contain more pebbles than boulders. This is exactly the kind of stuff that is visible all around Carlow and Kilkenny. A fine section is seen in it in the railway-cuttings for more than three miles on each side of the latter city ‡.

It would be difficult to explain these pebbly Boulder-clays on any other hypothesis than the above, even were they never found lying actually on the middle gravels, as they do in some places.

On the Geological Structure of the Tyrone Coal-fields. By Edward T. Hardman, *F.C.S., F.R.G.S.I., of the Geological Survey of Ireland.*

The Carboniferous rocks of this district appear to resemble somewhat those of the northern counties of England. The coal-bearing beds are true Coal-measures, but the underlying limestone is split up by numerous sedimentary beds, the calcareous members becoming more scarce towards the north, until finally the whole becomes similar to the Lower Carboniferous rocks of Scotland, to which horizon Professor Hull has referred the Coal-measures of Ballycastle, co. Antrim. They are partially covered by newer formations, Permian, Trias, Chalk, &c., to which, as well as the existence of some large boundary faults, is due the preservation of the two small patches of Coal-measures which form these coal-fields.

The succession of rocks in the neighbourhood of Coalisland and Dungannon is as follows:—

* Jukes's Manual of Geology, edited by Geikie, p. 707 *et seq.*

† Identified as the upper clay by its containing at the base quantities of water-worn pebbles, all well scratched.

‡ It is noticed in more than one locality in the Queen's County at a height of 1000 feet above the sea on the Coal-measure hills.

			feet.
Cretaceous	Upper Chalk with Flints.		
Triassic	Upper Bunter Sandstone.		
Coal-measures, probably 1930 feet.	*Middle Coal-measures.*—Consisting of sandstones with soft shales and very thick beds of fire-clay, ironstones, and many coal-seams, often thick. *Lingula squamiformis* and *Anthracosia*, also fish-remains very abundant. Ferns, &c. about		930
	Lower Coal-measures.—Chiefly hard sandstones and grits, sandstone slate, and hard shales, with but few coal-seams or ironstones. Plants very abundant. *Goniatites* and *Lingula* occasionally. Fish-remains rather scarce. (? Gannister-beds.) probably		1000
Millstone-grit	Coarse grits and sandstones probably		200
Yoredale Shales	Black calcareous and non-calcareous shales with bands of limestone, sandstone, and clay-ironstone nodules		600
Upper Limestone	Crystalline and marly limestones with sandstone bands	In all perhaps about	2000
Calp	Impure limestones, shales, and sandstones		
Lower Limestone	Sandy limestones, shales, sandstone, and dolomite		

The author having explained his reasons for adopting the above classification and thicknesses, went on to describe the coal-fields in detail, commencing with the Dungannon coal-field, which extends from near Dungannon to beyond Coalisland; and which, though of small area, is extraordinarily rich in coal-seams, for it contains from 22–24 coal-beds, at least 13 of which are workable, while 17, containing about 42 feet of workable coal, lie in 300 yards of strata. They are all highly bituminous coals, and two of them contain valuable bands of cannel. In a series of analyses of these coals the author found the amount of volatile matter ranged from 37·5 to 47·8 per cent., so that all are highly adapted for gas manufacture. With all this, firedamp is almost unknown.

In the upper measures there are important deposits of fire-clay, which are extensively used in brick- and tile-works. The ironstones are not sufficiently abundant perhaps to work; but the author found the amount of metallic iron in six specimens to range from 21·70 to 35·50 per cent. As to the resources, he considered that there must be from 30–40 millions of tons of coal yet untouched, only counting the coals of a yard thick and upwards, and including the smaller coals 9 millions more.

This coal-field is bounded on the north-west by a large fault, which brings down the Coal-measures on the south against the Calp and Lower Limestone. It must therefore have a downthrow of more than 2000 feet.

North of it the limestone is found covered with triassic strata, without any intervening Coal-measures for 3½ miles, when a small trough of the Middle Coal-measures containing the four upper Coalisland coals is found, inlaid by means of several faults on the north, south, and west, amongst the other rocks. This coal-field* is but 2½ miles long by ¼ mile wide, yet must contain the whole series of Middle and Lower Coal-measures, Millstone-grit, and Yoredale beds. However, the upper beds are nearly worked out; and supposing all the others to exist, the supply can hardly be more than about 800,000 tons. The coal-field may still stretch away to the eastward under the newer strata.

A little to the north of this coal-field a little patch of Permian Limestone is found resting immediately on the Carboniferous Limestone.

The author proceeded to explain when and how the two coal-fields became isolated from each other, and why in the immediate vicinity of these thick Coal-measures the Permian or Trias are found reposing directly on the Limestone. At the close of the Carboniferous period those rocks were forced into a series of flexures or folds ranging east and west, owing to the influence of forces acting from

* The Annaghone Coal-field.

the northward, as Professor Hull has already shown occurred in England during that time*, and it is interesting to find the results of the same forces traceable here. Denudation following, resulted in a set of plains or edges of limestone, and troughs or basins of Coal-measures, all of which were overlapped by the deposition of Permian or Triassic beds. (A part of the country between the two coal-fields represents one of these limestone plains.) On subsequent denudation, and post-triassic faults occurring, some portions of the Coal-measures would be laid bare or saved beneath the newer formation, while in other places close by there would be an overlap of the newer rock on limestone, apparently as if the whole effect, faulting and all, on the Carboniferous rocks had been produced before the Triassic period. As the whole district is cut up by faults and rock exposures are few, the evidence of those flexures is now obscure; yet on the whole there is enough to justify this assumption, and in this way only can the phenomena observed be accounted for.

In conclusion the author referred to the addition made to the palæontological knowledge of these coal-fields since the Government Survey of them was undertaken, he and his colleague, Mr. W. H. Baily, F.G.S., F.L.S., with Mr. E. Leeson, having obtained many shells, bivalves, *Goniatites*, &c., together with plants and fish-remains, the discovery of the last being due to Mr. W. Molyneux, F.G.S., of Burton-on-Trent, who first pointed them out to the author.

A Synopsis of these fossils, compiled from a list kindly furnished by Mr. Baily of the specimens which he has been able up to the present to examine, is appended.

List of Fossils compiled from Mr. Baily's Notes.

PLANTÆ.

Sphenophyllum saxifragifolium.
Stigmaria ficoides.
Nœggerathia dichotoma.
Sagenaria rimosa, and Sigillaria.
Sphenopteris irregularis (latifolia).
—— tridactylites.
Lepidodendron selaginoides.
Calamites cannæformis.
Lepidophyllum.
Lepidostrobus.
Pecopteris.

MOLLUSCA.

Brachiopoda.
Lingula squamiformis.
Athyris, sp.

Lamellibranchiata.
Sanguinolites attenuatus.
Modiola Macadami.
Anthracosia.

Cephalopoda.
Goniatites crenistria.
Orthoceras, sp.

CRUSTACEA.

Ostracoda.
Leperditia, sp.

VERTEBRATA.

Pisces†.
Helodus planus?
Palæoniscus.

On the Age and Mode of Formation of Lough Neagh, Ireland. By EDWARD T. HARDMAN, *F.C.S., F.R.G.S.I., of the Geological Survey of Ireland.*

After describing the position of Lough Neagh, one of the largest lakes in Europe, the author referred to the fact that its general direction agreed very fairly with that of the principal ice-flow which had glaciated the district, and might therefore be supposed to indicate a glacial origin. The object of the paper was to show that this is not so, but that the lake was formed long before the Glacial period.

The geology of the district was briefly described. On three sides of the lake lies the basalt, rising as it recedes into considerable altitudes; on the east and north-

* "On the Physical Features of Lancashire and Yorkshire," by E. Hull, F.R.S., Quart. Journ. Geol. Soc. Lond. vol. xxiv.

† Scales, palates, and spines, &c. only obtained.

east Black Mountain, Divis, Slemish, and Slieve-na-nee (1782 ft.); on the north the ground is comparatively low; on the north-west and west, Keady, Donald's Hill, Carntogher (1572 ft.), Craigs-na-shoke (1996 ft.), and Slieve Gallion Carn (1625 ft.). On the south of the lake, forming very low ground, overlying the basalt and extending some miles inland, is a thick deposit of plastic clays and sands, with lignite and clay-ironstone.

The basaltic ground terminates on the east and west in high escarpments, from underneath which emerge the mesozoic strata, viz. Chalk, Greensand, Lias, and Trias (Keuper and Bunter), all of which can be traced on the east from Carrickfergus and Belfast, along the valley of the Lagan to Portadown, round by the south of the clay deposit, and continuing on the west by Stewartstown, Moneymore, and Magherafelt. Underlying these, following the same line, further back, are the various members of the Palæozoic strata, Permian, Carboniferous, and Silurian, with, on the west, the metamorphic rocks and red granite of Slieve Gallion.

In this circuit the ground rises more or less rapidly as it recedes, but the general dip of the strata, especially the newer, is towards the Lough.

The principal inflowing rivers are the Upper Bann, Blackwater, Ballinderry river, Moyola, and Mainwater—the outgoing one being the Lower Bann, flowing from the north-west of the Lough, through Lough Beg, and falling into the sea below Coleraine.

The most important, as well as most ancient, of these are the Upper Bann and Blackwater, draining the country to the south, and passing through what was formerly the delta of one or other of them—the great clay-deposit already mentioned.

These beds have been referred to before by previous writers, Sir Richard Griffith, Portlock, and others, but have not been definitely placed with regard to the basalt and drift. They lie under a deposit of drift often more than 50 feet thick, are very thick, and extend from Ballinderry river on the west, round by Coalisland, Roxborough Castle, Portadown, &c., ending at Sandy Bay, co. Antrim, and reaching a distance of six miles from the shore at one place. They consist of stratified grey and blue clays, sand, and sandstone, occasionally with iron-pyrites, irregular beds of lignite, and hard siliceous clay-ironstones. In these reed-like plants and well-preserved dicotyledonous leaves are found, and in the clays fragments of black wood, apparently pine and oak, but as yet no trace of a fauna. They dip towards the lake at from 2°–3°, which would give a thickness of 1200 feet at the shore. This must be excessive, yet as they were bored (without being fully penetrated) to a depth of over 260 feet* (allowing for drift) in Annaghmore, more than two miles from the shore, the theoretical depth being 250 feet, it is possible that in some places their thickness may be 500 feet.

The deepest part was therefore originally at the southern end, whereas it is now at the northern, and only 105 feet at most. An ice-formed lake would be deepest near where the ice first entered.

The various localities where the clays may be seen (in one place resting on the basalt) having been described, the author noticed the plentiful occurrence of round pebbles of basalt and chalk flints in them and some beds of lignite; but in no instance was any of the celebrated silicified wood obtained *in situ*, notwithstanding the numerous excavations that have been made for the raising of the clay for pottery manufacture. Nor does he consider that the celebrated specimens obtained at Sandy Bay by Barton, and referred to by Scouler, Portlock, and others, were true silicified wood at all; for they were black, capable of being cut by a spade, and only more or less stony, a description that would apply better to pyritous wood. The silicified wood is usually found in the drift, not only south, but also north of the Lough; and its real *locus* may, with most probability, be assumed to be the basaltic lignite beds.

The evidence for the order of superposition of the clay-beds was summed up as follows:—(1) In at least one instance a similar clay has been observed resting on the basalt. (2) That where the two have been found in juxtaposition, the form of the ground, not being an escarpment, shows that the soft beds lie uppermost.

* Griffith, Second Report of Railway Commissioners, p. 22; also Twenty-second Report Brit. Assoc. p. 48; and Portlock's 'Geological Report,' p. 167.

(3) That pebbles of basalt are found in them. (4) That while numerous junctions of the chalk and basalt are seen, these clays are never found between them. (5) The recent aspect of the plant-remains prevents the supposition that the clays belong to an older period than the Chalk. The only place left for them is therefore between the basalt and the drift, which is seen resting on them.

Geologists have hitherto differed very seriously as to the age and position of these beds. Portlock has classed a portion of them with the *Nucula*-clays of Derry *, which belong to the drift; Griffith with the Bovey Tracey beds †; Prof. King above these ‡; Jukes has mapped them as Pleistocene, and Mr. G. H. Kinahan § suggests that they are a Preglacial drift: the author proposes to class them as *Pliocene*, on the following grounds:—

The basaltic outflow was followed by a period of great disturbances and dislocations, accompanied by very extensive denudations, sufficient to remove in many places as much as 1000 or 2000 feet of solid strata. Afterwards the Lough Neagh clays were deposited. Thus we have unconformability together with an immense lapse of time, which alone would justify us in placing the basalt (of acknowledged Miocene age) and the clays in different systems. Besides, the plant-remains have an exceedingly recent aspect, and the lignite is often not far removed from peat. On the whole, the beds bear some resemblance to the Older Pliocene of the Val d'Arno as described by Lyell ('Student's Elements of Geology,' p. 184). The author was glad to say that the present classification has met with the sanction of Prof. Ramsay and Prof. Hull. These clay-beds must occupy an area of not less than 180 square miles.

Around the mouth of the Moyola are clay-beds containing erect tree-stumps, forming a small delta of Postglacial date.

Former level of the Lough.—The clays being found at a height of 120 feet above the sea in many places, prove that the waters formerly rose to at least that level, whereas they are now but 48 feet above sea-level. They were most probably higher, as much of the ancient mud must have been denuded away since its deposition; but if the shore be contoured at even 120 feet, the former area of the lake must have been nearly double what it is now, or nearly 300 square miles. The author considered the evidence to prove that the lake extended southward towards Armagh, and but little more to the north than it now does, the deepest part lying also to the south.

Time and Mode of Formation.—It is clear, therefore, that the lake was formed at the close of the Miocene period (the Pliocene clays denoting the time of its completion), and it is therefore unlikely that ice could have had any thing to do with it, the slight trace of ice-action elsewhere during that time being most probably due to a local glacier; but to produce any thing like the effects here to be seen, such as the removal of thousands of feet of rock over hundreds of square miles, would have necessitated a very intense degree of glaciation, and such as must have left distinct traces behind it. Mr. J. F. Campbell, F.G.S.‖, has indeed attributed the shaping of this district to the ice of the last Glacial epoch. But this opinion is hardly tenable; for the lake, and consequently the general physical geography of the district, was formed previous to that time.

The author's theory of the formation of the lake is this:—After the basaltic flow had ceased, subsidences over a large area took place, corresponding with certain lines of parallel and transverse faults of considerable force, which can be proved to extend across the ground comprising the plain and bed of Lough Neagh. Their general effect would be to give to the face of the country a rudely depressed shape, consisting of a series of steps to the north, north-west, and south, thus determining the chief flow of water into the hollow centre, and (denudation proceeding *pari passu*) gradually shaping out something like a lake-basin. The egress of the water was provided towards the east, along what is now the valley of the Lagan, which,

* Portlock's 'Geological Report.'

† Report to accompany Geological Map, 1838; also Report British Association, 1852, p. 48.

‡ Synoptical Table of Rock Groups.

§ Geological Magazine, vol. i. p. 173.

‖ Quart. Journ. Geol. Soc. London, May 1873.

no doubt, was commenced somewhere about this period. Eventually the depression increasing towards the centre of the faults crossing the lake, caused a lateral upheaval on each side, giving the finishing touch to the basin depression and causing an inflow from all sides. The outflow may now possibly have begun to take its way along the great valley of depression which it still occupies. In the course of time large rivers carried down immense quantities of detritus into the water-filled hollow, and spread it into a great lake-delta, silting up the greater part of the lake. Finally, it is possible that some depression of the country to the north ensued, draining the lake to some extent; for near Belfast a clay-deposit containing *Nucula oblonga*, &c. has been found about 120 feet above the sea, which is referred to Newer Pliocene age. It is unnecessary to trace the history of the Lough past this point, because the physical geology has remained essentially the same to the present day.

The basin could not have been of prebasaltic age, because the Chalk is everywhere of nearly uniform thickness, and must have formed a flat surface, probably a plain of marine denudation, when the basalt was deposited on it, both together being afterwards upheaved around the edges. Moreover, all the most important faults in the district being of postbasaltic age (in part at least), the previous features of the country must have been quite distinct from the appearance they afterwards presented.

Details of the probable mode of Formation of the Lough.—The author proceeded to describe the faults which crossed the Lough, premising that they left little or no trace, either in the shape of the ground or of the lake margin; all that he stipulated for being that they were the means of determining the flow of water into, and the removal of detritus out of, the centre in the first instance.

The principal fault is that forming the north-west boundary of the Dungannon coal-field (where it has a throw of at least 2000 feet) running N.W., no doubt crossing the lake, and most probably joining the great Templepatrick fault, which has a downthrow of some hundreds of feet to the same side (the south). It appears to die out at either extremity.

North of the last, the southern boundary fault of the Annaghone coal-field has been traced nearly parallel to it, with a downthrow also to south, proved in a trial for coal to be at least 300 feet, but considered to be much more.

Further north are two large faults running towards the Lough, by Coagh; and these throwing *towards* each other would form a trough, the direction of which would coincide with the deep part of the lake.

Further on towards Slieve Gallion, and in the country around it, are numerous faults, which have a considerable share in modifying the shape of the country.

On the east side besides the Templepatrick fault there are several which can be observed in the high grounds about the valley of the Lagan, and whose general downthrow is rather towards the Lough.

All the above are either partially or entirely in age postbasaltic. A large post-triassic fault has been observed near Dungannon, which if continued, and that it is also *postbasaltic*, would pass south of the lake and upheave the ground in the same direction.

The effect of all these faults would be, therefore, to cause a great depression of the ground now occupied by Lough Neagh; but before the final completion of that basin, the valley of the Lagan was denuded.

The author concluded with evidence as to the enormous amount of denudation which took place over the basaltic district during the latter part of the Miocene period, and suggested that a great part, if not the whole, of Ireland may have also suffered at the same time, finally summarizing the chief points dwelt on as follows.

Recapitulation.—(1) The Lough is of an age intermediate between the Lower Miocene and the Glacial periods. (2) It is not a true rock-basin, and could not have been formed by ice-action either of Miocene or subsequent age, but is part of an area of depression, and is due to the existence of one or more series of faults, assisted by subaerial denudation. (3) That the extensive deposit of clays and sands, &c. found on the southern shore and for some miles inland is the delta of a former large river, which flowed very much in the same course that either the

Upper Bann or the Blackwater does now. (5) That these clays are of considerably later date than the basalt, and that the silicified woods may with all probability be referred to the latter. (6) By the help of these clays we learn that the existing physical geology, and the main features of the surrounding country, are due to a period newer than the age of the basalt, but more ancient than the great Glacial epoch, and that the great denudation which has affected the north of Ireland at least belongs to the same time.

Sketch of the Geology of the N.E. of Ireland. *By* Professor Harkness, *F.R.S.*

On the Progress of the Geological Survey of Ireland. *By* Prof. Hull, *F.R.S.*

In exhibiting the new Index of Geological signs and colours, which had just been prepared for the Geological Survey of Ireland, Professor Hull gave a short sketch of the origin and progress of the Survey, observing that it had originated in 1832 with that of the late General Portlock and his assistants, who had published the well-known 'Report on the Geology of Londonderry, Tyrone, and adjoining districts' (1843). Along with this it had been intended to publish exhaustive reports on the botany, zoology, and mineralogy of the districts; and Mr. Oldham, afterwards the Director of the Survey, was appointed to undertake the last-named department.

Afterwards, however, the project of extending the Survey to other branches of Natural History than that of Geology was abandoned; and it was determined by the Government of Sir Robert Peel to consolidate the Surveys of the United Kingdom under one head, and Sir H. T. De la Beche was appointed the first Director-General (in 1844), while the Geological Survey of Great Britain was placed under the immediate direction of Professor Ramsay, and that of Ireland under Captain (afterwards Colonel) Sir H. James, who was succeeded by Professor Oldham, with a small staff of assistants. These officers commenced operations in the vicinity of Dublin, and southward through Wicklow into Wexford. On Professor Oldham being appointed to the Geological Survey of India, he was succeeded in the Directorate by the late Professor Jukes, who, with a slightly increased staff of surveyors, including the late Mr. Du Noyer and Mr. Kinahan, the present District Surveyor, completed the survey of a very large portion of the south, centre, and west of Ireland.

The districts recently completed are those of Connemara and West Mayo by Messrs. Kinahan, Warren, and Symes, of the Mourne Mountains by Mr. Traill, of the vicinity of Antrim by Mr. Duffin, the Dungannon district by Mr. Hardman, and that of Armagh by Mr. Egan, together with other portions of Westmeath, Longford, and Mayo by Messrs. Wilkinson, Cruise, and Leonard.

These maps are surveyed on the scale of 6 inches to a mile; and the field maps are afterwards reduced and engraved on the Ordnance maps at a scale of one inch to a mile, which are published through the agents both in Belfast and Dublin. These maps are not generally hill-shaded; but it is intended to publish all the geological details of the district, north of a line drawn from Clewe Bay on the west to Dundalk Bay on the east, on maps having the physical features shown by shading.

The survey of the Dungannon coal-field has just been completed, and the results are being prepared for publication. This is also true with regard to the Leitrim and Roscommon coal-districts, while a fresh survey is being carried out of the Leinster coal-field.

Great pains is also being taken to portray accurately the extent of the deposits of iron-ore of co. Antrim, and considerable advance has been made in the survey of that district.

Professor Hull then referred to the Geological Map of Sir R. Griffith, the first ever constructed for Ireland, expressing his high appreciation of its beauty and accuracy.

Note on the so-called Crag of Bridlington. *By* J. Gwyn Jeffreys, *LL.D., F.R.S.*

In compliance with a request of the late Professor Phillips, made not long before his lamented death, the author examined all the collections of fossil shells from the

celebrated Crag-bed at Bridlington; and he furnished the Professor with a *catalogue raisonnée* of the species for the new and forthcoming edition of his work on the Geology of Yorkshire. Dr. Jeffreys went lately, with Mr. Leckenby, to Bridlington, when they ascertained that the Crag-bed lay under the boulder-clay, and rested unconformably on a bed of Liassic shale of a purplish colour, which in one place appeared to have been triturated and redeposited in the form of clay. In this purplish clay they found a specimen of *Turritella erosa* (an Arctic and North-American shell), besides several other species which are common to the boulder-clay and Bridlington bed. All the species from the Bridlington bed are high northern and are now living. They are sixty-seven in number; and a list is subjoined. The author suggested that this deposit of shells might have originated either in a deviation of the great Arctic current at a very remote period, or in glacial conditions. It had clearly no relation to the Norwich Crag, as was once imagined to be the case.

The present direction of the Arctic current has been to a certain extent shown by the expeditions conducted by the author in H.M.S. 'Porcupine,' during the years 1869 and 1870, to traverse the North Atlantic along the west coast of Ireland as well as the Bay of Biscay; and there is no doubt that it formerly reached that part of the Mediterranean where Sicily is. One of the species (*Nucula Cobboldiæ*) has been hitherto known from Japan only; but it is probable that when the coralline and deep-sea zones of the circumpolar ocean shall have been explored, this species will be discovered in the highest latitudes.

The author is inclined to reject from the list of Bridlington fossils the following species, viz. *Mytilus edulis, Cardium edule, Littorina litorea, L. rudis,* and *Purpura lapillus,* because they are littoral, and therefore not likely to be associated with species which belong to the coralline zone, such as *Rhynchonella psittacea, Venus fluctuosa, Dentalium striolatum, Admete viridula,* and *Columbella Holbölli.* These littoral shells may have come from the boulder-clay, and been accidentally mixed with the shells from the deposit under consideration.

Bridlington Fossil Shells.

B., British Museum; L., Leckenby in Cambridge University Museum and at Scarborough; P., Collection of Professor Phillips in Oxford University Museum; W., S. V. Wood, 'Monograph of Crag Mollusca;' W. jr., S. V. Wood, junr.'s list; Wd., S. P. Woodward's list; Y., York Museum.

No.	Name of Species.	Where seen or noticed.	Synonyms and Remarks.	Where living.
	BRACHIOPODA.			
1.	Rhynchonella psittacea, *Chemnitz.*	W., W. jr., Wd.	....	Arctic seas; Shetland; N.E. America; N. Pacific.
	CONCHIFERA.			
2.	Anomia ephippium, *Linné.*	B., W., W. jr., Wd., Y.	....	Iceland to Madeira; Labrador to Cape Cod.
3.	Pecten Islandicus, *Müller*	B., L., W., W. jr., Wd., Y.	*P. pusio*, S. V. Wood.	Arctic seas to Bergen; N.E. America; Japan.
4.	Mytilus edulis, *L.*	W., W. jr., Wd.	....	N. Atlantic and N. Pacific, as well as polar.
5.	—— modiolus, *L.*..........	W., W. jr., Wd.	....	N. Atlantic to Cork, and N. Pacific; not known as polar.
6.	Nucula Cobboldiæ, *Leathes.*	B., L., W., W. jr., Wd., Y.	*N. insignis*, Gould.	Japan.

No.	Name of Species.	Where seen or noticed.	Synonyms and Remarks.	Where living.
7.	Nucula tenuis, *Montagu*; and var. inflata.	L., W., W. jr., Wd.	....	Spitzbergen to the Ægean; N.E. America; Behring's Straits to Japan.
8.	Leda minuta, *Müll.*; and var. buccata.	L., W., W. jr., Wd.	*L. caudata*, Donovan.	Arctic seas to Bay of Biscay; N.E. America; N.W. America to Japan.
9.	—— pernula, *Müll.*	W., W. jr., Wd.	....	Spitzbergen to Danish coasts.
10.	—— limatula, *Say*	W., W. jr., Wd.	*L. oblongoides*, S. V. Wood.	Arctic seas; N.E. America.
11.	Pectunculus glycymeris, *L.*	L., W., Wd., Y.	....	Loffoden Isles to the Canaries; Japan.
12.	Montacuta bidentata, *Mont.*	Coll. Bowerbank (*fide* Forbes).	....	Norway to Madeira and Sicily.
13.	Cardium Islandicum, *L.*	L., W., W. jr., Wd., Y.	*C. decorticatum*, S. V. Wood.	Arctic seas in both hemispheres; Japan; N.E. America.
14.	—— edule, *L.*	P., W., W. jr., Wd., Y.	....	Norway to the Caspian and Mediterranean.
15.	Cardita borealis, *Conrad.*	B., L., P., W., W. jr., Wd., Y.	*C. analis*, S. V. Wood.	N.E. America; Japan.
16.	Cyprina Islandica, *L.* ...	B., L., P., W., W. jr., Wd., Y.	....	Upper Norway to Arcachon; N.E. America.
17.	Astarte sulcata, *Da Costa*; and var. elliptica.	B., L., W., W. jr., Wd., Y.	The variety is *Venus compressa*, L.	Spitzbergen to Scotland; N.E. America; N. Atlantic and Mediterranean; N. Pacific.
18.	—— depressa, *Brown* ...	L., W., W. jr., Wd.	*A. crebricostata*, Forbes; *A. Warhami*, Hancock.	Arctic seas in both hemispheres to north of Hebrides and Cape Cod; Behring's Straits.
19.	—— borealis, *Ch.*; var. Withami, and monstr. mutabile.	B., L., P., W., W. jr., Wd., Y.	*Crassina arctica*, Gray, and many other synonyms.	Arctic Ocean to Kiel Bay; N.E. America; Sea of Ochotsk.
20.	—— compressa, *Mont.*; and var. striata.	B., L., P., W., W. jr., Wd., Y.	Many synonyms. Not *Venus compressa*, L.	Spitzbergen to coast of Portugal; Baffin's Bay to Cape Cod; N. Pacific.
21.	Venus fluctuosa, *Gould*...	B., W., W. jr., Wd., Y.	....	Arctic seas; N.E. America; Japan.
22.	Tellina balthica, *L.*	B., L., P., W., W. jr., Wd., Y.	*T. solidula*, Pulteney.	Circumpolar; N. Atlantic to Madeira and Cape Cod; N. Pacific.
23.	—— calcaria, *Ch.*; and var. obliqua.	B., L., W., W. jr., Wd.	....	Spitzbergen to the Baltic; Greenland to Cape Cod; Behring's Straits to Japan.
24.	Donax vittatus, *Da C.*...	L. & J. G. J.	*D. trunculus*, L. (partim); *D. semistriatus*, Poli.	Upper Norway to Mediterranean.
25.	Mactra solida, *L.*; var. elliptica.	B., L., W. jr., Wd.	....	Iceland to Bay of Biscay.
26.	Thracia prætenuis, *Pult.*	Y.	....	Ireland to Sicily.

No.	Name of Species.	Where seen or noticed.	Synonyms and Remarks.	Where living.
27.	Corbula gibba, *Olivi*......	P.	*C. nucleus*, Lamarck.	Loffoden Isles to the Canaries and Ægean.
28.	Mya arenaria, *L.*	W.,W. jr., Y.	....	Arctic seas to Adriatic; N.E. America; N. Pacific.
29.	—— truncata, *L.*	B., L., W., W. jr.,Wd., Y.	....	Same range as that of *M. arenaria.*
30.	Saxicava Norvegica, *Spengler.*	B., L., P.,W., W. jr., Wd.	....	Iceland to Dogger Bank; N.E. America; N. Pacific.
31.	—— rugosa, *L.*............	B., L., P.,W., W. jr.,Wd., Y.	....	Universally distributed.
32.	Pholas crispata, *L.*	B., L., P., W., W. jr., Wd., Y.	....	Iceland to Bay of Biscay; N.E. America; N. Pacific.
	SOLENOCONCHIA.			
33.	Dentalium entalis, *L.* ...	B.	....	Iceland to Bay of Biscay.
34.	—— striolatum, *Stimpson.*	B., L., W., W. jr.,Wd., Y.	*D. abyssorum*, Sars.	Arctic seas to Bay of Biscay; N.E. America.
	GASTROPODA.			
35.	Lepeta cæca, *Müll.*	L.	....	Arctic seas to Hebrides; N.E. and N.W. America.
36.	Puncturella noachina, *L.*	B., L., W., W. jr., Wd.	....	Arctic seas to Bay of Biscay; N.E. America; N. Pacific.
37.	Trochus varicosus, *Mighels and Adams.*	B., L., W., W. jr.,Wd., Y.	*Margarita elegantissima*, Bean, and other synonyms.	Spitzbergen to Norway; Japan; N.E. America.
38.	Littorina litorea, *L.*	P.,W.,W. jr., Wd.	....	Arctic seas to the Adriatic; N.E. America.
39.	—— rudis, *Maton*	L. & J. G. J.	....	Arctic seas to Azores and Adriatic; N.E. America; Japan.
40.	Turritella terebra, *L.*......	P., W.,W. jr., Wd., Y.	*T. communis*, Lam.	Loffoden Isles to the Adriatic.
41.	—— erosa, *Couthouy* ...	B., L., W., W. jr.,Wd., Y.	*.polaris*(Beck), Möller; *T. clathratula*, S. V. Wood.	Arctic seas and N.E. America.
42.	Scalaria Grœnlandica, *Ch.*	P., L.. W., W. jr.,Wd., Y.	....	Arctic seas to north of Hebrides; N.E. America.
43.	Natica Islandica, *Gmelin*	L.,W.,W. jr., Wd., Y.	*N. helicoides*, Johnston.	Arctic seas to Cork; N.E. America.
44.	—— Grœnlandica, *Beck*	B.,L.,P.,Wd., W. jr., W., Y.	....	Arctic seas to Straits of Gibraltar; N.E. America; N. Pacific.
45.	—— affinis, *Gm.*; and var. occlusa.	B., L., W., W. jr., Wd., Y.	*N. clausa*, Broderip and Sowerby.	Arctic seas to Bay of Biscay; N.E. America; N. Pacific.
46.	—— Montacuti, *Forbes*	W., W. jr., Wd.	....	Iceland to Bay of Biscay.

No.	Name of Species.	Where seen or noticed.	Synonyms and Remarks.	Where living.
47.	Trichotropis borealis, *Broderip and Sowerby.*	B., L., W., W. jr., Wd., Y.	....	Arctic seas to west of Ireland; N.E. America; N. Pacific.
48.	Admete viridula, *Fabricius.*	B., L., W., W. jr., Wd., Y.	*Cancellaria costellifera*, J. Sowerby.	Spitzbergen to Bay of Biscay; N.E. America; Japan.
49.	Purpura lapillus, *L.*	L., P., W. jr., Wd.	....	Arctic seas to Mogador and Minorca; N.E. and N.W. America.
50.	Buccinum undatum, *L.* ...	L., P., W., W. jr., Wd., Y.	....	Iceland and North Cape to Bay of Biscay; N.E. America; N. Pacific.
51.	Trophon truncatus, *Ström.*	B., L., W. jr., Wd.	....	Greenland to South of Ireland; N.E. America.
52.	—— clathratus, *L.*; and var. Gunneri.	B., L., P., W., W. jr., Wd., Y.	*T. scalariformis*, Gould.	Arctic seas to Norway; N.E. and N.W. America; Japan.
53.	—— Fabricii, *Beck*	L., P., W., W. jr., Wd.	*T. craticulatus*, Fabr., not Linné.	Arctic seas in both hemispheres.
54.	—— latericeus, *Müll.* ...	L.	....	Arctic seas to north of Hebrides.
55.	Fusus despectus, *L.*; and monstr. contrarium.	B., L., P., W., W. jr., Wd.	....	Arctic seas to coasts of Portugal; N. Pacific.
56.	—— curtus, *Jeffreys*; and var. expansa.	B., L., P., W., W. jr., Wd., Y.	*Trophon gracile*, *Sabini*, and *ventricosus*, S. V. Wood.	N.E. America.
57.	—— Leckenbyi, *S. V. Wood.*	L., W.	*F. turgidulus*, Jeffr. MS.	Between Shetland and the Färoe Isles.
58.	—— Spitzbergensis, *Reeve.*	B.	....	Spitzbergen and Wellington Channel.
59.	—— propinquus, *Alder*	W., W. jr., Wd.	A doubtful identification.	Upper Norway to Cork.
60.	—— Sarsi, *Jeffr.*	L.	....	Norway and south of Färoe Isles.
61.	Columbella rosacea, *Gould.*	B., W., W. jr., Wd.	*C. Holböllii* (Beck), Möller.	Spitzbergen to north of Hebrides; N.E. America.
62.	Pleurotoma pyramidalis, *Ström.*	B., W., W. jr., Wd., Y.	*Fusus pleurotomarius*, Couth.	Spitzbergen to Bergen, Greenland to Cape Cod.
63.	—— violacea, *Migh. and Ad.*	B., L., W., W. jr., Wd.?	*Defrancia cylindracea* (Beck), Möller.	Arctic seas in both hemispheres; Norway.
64.	—— elegans, *Möll.*	L., W., W. jr., Wd.	....	Spitzbergen and Greenland; Norway.
65.	—— turricula, *Mont.*; and var. nobilis and excavata.	B., L., P., W., W. jr., Wd., Y.	*P. Dowsoni*, S. V. Wood, and other synonyms.	Arctic seas to Bay of Biscay; N.E. America.
66.	—— harpularia, *Couth.*	L., W.	*P. robusta*, S. V. Wood.	Norway and N.E. America.
67.	—— Trevelyana, *Turton*	B., L., P., W., W. jr., Wd., Y.	*Defrancia Woodiana*, Möll.	Arctic seas in both hemispheres to Dogger Bank and Cape Cod; N.W. America.

Notes on Cavern Exploration, by M. Emilion Frossard, in the Vallée de Campan, Hautes-Pyrénées, France. By Sir WILLOUGHBY JONES, *Bart.*

On Geological Maps and Sections of West Galway and South-west Mayo. By G. H. KINAHAN, *F.G.S.*

On the Occurrence of the Middle Lias at Ballycastle. By G. LANGTRY.

The author stated that Mr. William Gray first directed attention to the occurrence of the Middle Lias in the county of Antrim. It is his impression, however, that the area in which it is likely to be found is very circumscribed; indeed some have gone so far as to affirm that its presence is only due to boulders having been transported thither, by glacial action, from some of the western islands of Scotland. But if this be so, why are the boulders not much more widely distributed? The author had not seen these blocks under such favourable circumstances as to determine accurately whether they bear the marks of ice-action; certainly none of those which he saw were polished, and any striations might have resulted from workmen's tools, as all the blocks had been exhumed either in constructing wells, flax-"*dubs*," or other excavations. One thing, however, is certain, that in the neighbourhood of the "Workhouse," Ballycastle, no cuttings to any considerable depth have been made without disclosing some of these *Liassic* blocks. Unfortunately no outcrop occurs affording facilities for a thorough examination. Another and very powerful reason why it is likely to be found *in situ* is that at Ballintoy, a few miles off, we have a fine section of the Rhætic and Lower Lias beds.

Mr. Gray has stated that the following species had been identified and tabulated:—*Hybodus reticulatus*, Ag.?; *Ammonites margaritatus*, Bl.; *Pitonillus turbinatus*, Moore; *Pecten liasinus*, Nyst; *Pecten acutiradiatus*, Schloth.; *Plicatula spinosa*, Sow.; *Cypricardia cucullata*, Goldf.; *Isocardia cingulata*, Goldf.; *Limea acuticosta*, Goldf.; *Avicula novemcostæ*, Brown; *Rhynchonella acuta*, Sow.; *Rhynchonella variabilis*, Schloth.; *Waldheimia numismalis*; *Pentacrinus*, sp.

Since this list was made out the author has procured *Unicardium cardioides*, *Ammonites planorbis*, and two other Ammonites not yet identified; also three casts of *Pholadomya* and two of *Astarte*; as these latter are merely impressions, it is almost impossible to classify them.

Some of those fossils which have been mentioned are not confined to the *Middle Lias* alone, but are distributed more or less sparingly in the lower beds of the same formation; others, again, are almost exclusively confined to the *Middle Lias marls* in Ireland.

On a Remarkable Fragment of Silicified Wood from the Rocky Mountains. By H. ALLEYNE NICHOLSON, *M.D., D.Sc., F.R.S.E., and* W. H. ELLIS, *M.B., B.A.*

The object of this communication was a singular fragment of silicified wood which had been obtained from a fossil forest in Colorado. The forest is situated near Colorado City, about 7000 feet above the level of the sea, near Pike's Peak. It covers an area of from 1000 to 2000 acres, and exhibits numerous erect silicified stumps, which are placed all round a broad depression, at one time apparently occupied by an ancient lake. The stumps are usually three or four feet in height, and from ten to twenty feet in diameter, and the authors gave reasons for believing that they belonged to the same group as the "giant trees" (*Sequoia gigantea*) of California, if not specifically the same.

The specimen which formed the immediate object of this paper was a fragment about six inches in greatest length by three in width. Thin sections, examined under the microscope, exhibited woody fibres and medullary rays, but no disks could be detected. Chemically, the wood is completely fossilized, and consists essentially of silica. A chemical analysis yielded:—water and organic matter, 6·24; silica,

85·26; alumina, 5·35; lime, 6·79; magnesia and iron, traces. The most remarkable point, however, was the very peculiar form of the specimen, which led the authors to conclude that it was a chip cut artificially from the tree prior to silicification. The chief reasons for this conclusion were summed up as follows:—1. The specimen is a fragment of silicified wood, exhibiting clean and definite surfaces at each end, cutting directly across the fibres of the wood. It is inconceivable that the silicified wood of an erect or prostrate trunk, not buried in the earth, should have been subjected to any influences which could have produced a "jointed" structure such as is seen in many rocks; and if the surfaces in question were not produced by any edge-tool, the agency by which they were formed has yet to be pointed out. 2. The general form of the fragment is, precisely and in the minutest details, that of an ordinary chip cut by an axe. 3. The upper of the two supposed cut surfaces is curved in the same way as is often seen in modern chips when the axe has been blunt or has been loosely held in the hand. 4. The lower surface is an approximately clean-cut plane, but exhibits numerous successive ledges or inequalities corresponding with the concentric layers of the wood. Similar parallel ledges or steps can be observed in any recent chip, when the axe used has been blunt; and they are due to the fact that the edge of the axe has made a succession of slips in cutting through the successive concentric layers of the wood, these layers differing from one another in hardness.

The authors concluded, therefore, that the specimen was a chip cut by one of the prehistoric inhabitants of North America from one of the ancient Sequoias of Colorado by means of a copper axe.

On Favistella stellata *and* Favistella calicina, *with Notes on the Affinities of* Favistella *and allied Genera. By* H. Alleyne Nicholson, *M.D., D.Sc., F.R.S.E., Professor of Biology in the College of Physical Science, Newcastle.*

In this communication the author fully discussed the validity of the genus *Favistella*, Hall, and its relation to the older genus *Columnaria* of Goldfuss. It was shown that the *Favistella stellata* of Hall was beyond reasonable doubt identical with the form previously described by Goldfuss under the name of *Columnaria alveolata*. Strict adherence to the law of priority would, therefore, demand the suppression of the former. It was further shown, however, that the name of *Columnaria alveolata* had by general consent become fixed upon a coral from the Trenton Limestone of America, which differed essentially from the form so named by Goldfuss in his original description. The author concluded that one of three courses should be adopted:—1. *Favistella* and *Columnaria* may be considered identical. This would be strict justice, but would be attended with the inconvenience that a new genus would have to be founded for the reception of the forms which have usually been regarded as typical *Columnariæ*. 2. The genus *Columnaria*, as redefined by M'Coy and Hall, may be adopted, only those forms with rudimentary septa being included in it, whilst the forms with complete septa are placed under *Favistella*, Hall. 3. We may consider the development of the septa as in itself not a character of sufficient importance to justify generic separation. In this case it would simply be necessary to expand the genus *Columnaria* of Goldfuss so as to receive the forms assigned to the genus by subsequent writers. The genus would then include two groups of corals—one with marginal and rudimentary septa (*Columnaria* of M'Coy, Hall, &c.), the other with complete septa (*Columnaria* of Goldfuss and *Favistella* of Hall). This course appeared to the author to be upon the whole the most advisable one.

The author enumerated the characters of *Favistella stellata*, Hall, and described a new species under the name of *Favistella* (*Columnaria*) *calicina*, as follows:—Corallum aggregate, subhemispheric or pyriform, rarely exceeding three inches in diameter and two in height. Corallites more or less cylindrical, rarely prismatic, from less than one line to two lines in diameter, averaging one line and a half. The corallites are never completely amalgamated by their walls, and are only rarely in direct contact throughout their entire height. On the contrary, each corallite is enveloped in a strong and completely separate epitheca, marked by vertical ridges and encircling striæ, and they diverge from the base in such a manner that they are usually sepa-

rated from one another by more or less conspicuous intervals near their calices. Septa alternately large and small, twenty-eight or thirty in number altogether, the primary ones nearly reaching the centre, the secondary ones marginal. Tabulæ well developed, complete, about three in the space of one line. Increase by calicular gemmation, apparently in combination with parietal budding.

Description of Species of Alecto *and* Hippothoa *from the Lower Silurian Rocks of Ohio, with a Description of* Aulopora arachnoidea. *By* H. ALLEYNE NICHOLSON, *M.D., D.Sc., F.R.S.E.*

In this communication the author described the following fossils from the Hudson-River Group of South-western Ohio:—

1. *Hippothoa inflata,* Hall, sp.—This is the *Alecto inflata* described by Hall from the older formation of the Trenton Limestone. Though in certain respects resembling some of the species of *Alecto,* the author expressed the opinion that this beautiful little species was an undoubted *Hippothoa.* The cells are pyriform, attenuated below, uniserial, and springing directly from one another, and the oval cell-mouths are placed on the front faces of the swollen cells.

2. *Alecto frondosa,* James.—This species, named by Mr. U. P. James in his 'Catalogue of the Silurian Fossils of Ohio,' was now for the first time described by the author. It forms anastomosing networks or thin expanded crusts parasitic upon *Strophomena alternata.* The cells are generally dispersed in two, three, or more rows, long and tubular, immersed below, but elevated towards the apertures, which are circular, terminal, and of the same diameter as the tube itself.

3. *Alecto auloporoides,* Nicholson.—This is closely allied to the preceding, but is distinguished by its much more slender habit and graceful form, and by having its cells disposed in a double or single series. It presents a close superficial resemblance to *Aulopora arachnoidea,* Hall, from which, however, it can be readily distinguished.

4. *Alecto confusa,* Nicholson.—This species forms thin crusts enveloping the columns of Crinoids. The cells are larger and more prominent than in the two preceding species, and are more closely and irregularly arranged.

5. *Aulopora arachnoidea,* Hall.—The author gave a full description of this species for the purpose of separating it from *Alecto auloporoides,* which it closely resembles in external appearance. Though very similar to *Alecto* in many respects, it can be referred with considerable confidence to the genus *Aulopora.*

Descriptions of New Species of Polyzoa from the Lower and Upper Silurian Rocks of North America. By H. ALLEYNE NICHOLSON, *M.D., D.Sc., F.R.S.E.*

In this communication the author described the following new species of Polyzoa:—

1. *Ptilodictya falciformis,* Nich.—A large and beautiful form, allied on the one hand to *Escharopora recta,* Hall, and on the other hand to *Ptilodictya lanceolata,* Goldfuss, *P. gladiola,* Billings, and *P. sulcata,* Billings. *Loc.* Cincinnati Group, near Cincinnati, Ohio.

2. *Ptilodictya emacerata,* Nich.—A minute species allied to *P. fragilis,* Billings, from strata of the same age in the island of Anticosti. *Loc.* Cincinnati Group, Ohio.

3. *Ptilodictya flagellum,* Nich.—A species belonging to the same group as *P. gladiola,* Billings, and *P. falciformis,* Nich., but distinguished by its much smaller size, less width, and flexuous form. *Loc.* Cincinnati Group, Lebanon, Ohio.

4. *Ptilodictya? arctipora,* Nich.—It is doubtful if this curious species is a true *Ptilodictya,* but it presents some affinity with *P. raripora,* Hall, from the Clinton Group. *Loc.* Cincinnati Group, Cincinnati, Ohio.

5. *Ptilodictya fenestelliformis,* Nich.—This in some external respects might readily

be taken for a *Fenestella*, and even approaches certain species of *Chætetes* (*Monticulipora*); but its internal structure proves it to be an indubitable *Ptilodictya*. *Loc.* Cincinnati Group, Cincinnati, Ohio.

6. *Fenestella nervata*, Nich.—A form somewhat resembling *F. tenuiceps*, Hall, but distinguished by having the frond supported by strong, rounded, slightly diverging ribs, like the midribs of a multicostate leaf. *Loc.* Guelph formation, Cedarville, Ohio.

7. *Ceramopora Ohioensis*, Nich.—This very remarkable Polyzoon forms thin crusts upon various Brachiopods and Corals, and in its best preserved condition is very readily recognized by its diagonally intersecting cells, with thin and arched upper walls and oblique semicircular mouths. *Loc.* Cincinnati Group, Ohio.

Descriptions of New Species of Cystiphyllum *from the Devonian Rocks of North America. By* H. ALLEYNE NICHOLSON, *M.D., D.Sc., F.R.S.E.*

No less than seven species of *Cystiphyllum* have already been recorded as occurring in the Devonian rocks of North America, viz. *C. vesiculosum*, Goldfuss, *C. Senecaense*, Billings, *C. grande*, Billings, *C. sulcatum*, Billings, *C. Americanum*, Edw. & H., *C. aggregatum*, Billings, and *C. mundulum*, Hall. To these the author now added the following three species, all of which were obtained by him from the Corniferous Limestone of Canada and the State of Ohio.

1. *Cystiphyllum Ohioense*, Nich.—This is a very minute species, averaging not more than six lines in length, with a remarkably deep, pointed, and not oblique calice. It possesses very distinct septal striæ, but is not furnished with any radiciform prolongations of the epitheca. It is most nearly allied to *C. mundulum*, Hall, from the Devonian of Rockford, Iowa, but is distinguished by its smaller size, the smaller number of its septa, and its much deeper and more pointed calice. *Loc.* Common in the Corniferous Limestone of Columbus, Ohio.

2. *Cystiphyllum squamosum*, Nich.—This species is readily distinguished by its extraordinarily flattened and scale-like form, due to the extreme obliquity and shallowness of the calice, the flattening of the dorsal surface, and the total disappearance of the lateral surfaces. No other species of the genus even approaches *C. squamosum* in these characters, and these are therefore of themselves sufficient to characterize the species. *Loc.* Corniferous Limestone, Columbus, Ohio.

3. *Cystiphyllum fruticosum*, Nich.—This species is remarkable for being *compound*, and for forming large colonies composed of numerous cylindrical, straight or slightly flexuous corallites, which are about three lines in diameter, and are placed about two lines apart. The internal structure is that of *Cystiphyllum*. Its composite character sufficiently distinguishes *C. fruticosum* from all previously recorded species of the genus except *C. aggregatum*, Billings, and from this it is separated by its totally different form and mode of growth. *Loc.* Corniferous Limestone, Wainfleet and Walpole, Ontario.

On the Columnar Form of Basalt. By W. CHANDLER ROBERTS, *F.C.S.*

The author briefly stated what were the views hitherto held by geologists as to the method by which the jointed prismatic structure had been produced. He specially alluded to the experiments made in 1804 by Mr. Gregory Watt, who showed that when basalt was melted and slowly cooled, globular structures appeared in the solidifying mass, a fact which led Mr. Watt to believe that the mutual compression of such spheres resulted in the formation of hexagonal prisms. The author pointed out the objections to this theory, and described the results of experiments he had made on the effect of heat on certain brick-like masses of fire-clay and sand. When these masses are heated to redness (a point far below that at which they would fuse), they contract from 3 to 4 per cent., and the unequal strain which attends the contraction produces a columnar structure closely resembling that of certain beds of basalt which occur in the valley of the Ardèche.

This structure can be produced at will, but it is necessary that the fire-clay should not be uniformly heated.

He concluded by comparing the columnar form of starch, which had assumed its

form at the ordinary temperature, with that of these heated masses of fire-clay and with columnar basalt which has undoubtedly cooled from a fluid state.

On the Permian Breccias of the Country near Whitehaven. *By* R. Russell, *C.E., F.G.S., H.M. Geological Survey.*

The subject of this brief notice is the Permian breccia of the district near Whitehaven.

Besides its exposure on the coast at Barrowmouth, many detached patches of this breccia occur further inland, between Bigrigg Moor and Rowrah, being much more largely developed over the latter area than it is at the former place. The section at Barrowmouth is well known, but in the latter district it has not previously been described in any published memoir.

The author considered:—1st, its occurrence; 2nd, its composition; 3rd, its formation.

1st. From the coast it rises rapidly along the cliff to the top of the ridge, and winding round by Preston Hows runs down into the St. Bees valley near Stanley Engine; on the opposite side of the valley it shows itself in Parkhouse Beck, whence it extends from Lund Moor by Pallaflat to Egremont. The line thus roughly traced is the northern boundary of the main portion of the Permian rocks, which, dipping to the south-west, extend southward into the Furness district.

Northwards the St. Bees sandstone is brought in from Scalegill Hall to north of Summer Grove by the Crowgarth and Ingwell faults, and the breccia crops out from under this sandstone in the valley near Keekle cottage. It also occupies a narrow strip between two parallel faults, having a N.W. and a S.E. direction, extending from Frizington Hall across Weddiker to north of Walkmill Bridge. West of Frizington Hall a fault puts in the St. Bees sandstone at Rheda, but on the upcast side of the fault east of Rheda the breccia forms a well-marked ridge from near Millyeat to Howgate.

Eastwards it again occurs on the downcast side of the Yeathouse fault, and is seen in the Whitehaven, Cleator, and Egrement Railway near Yeathouse station gradually to pass up into the Permian sandstone, the angle of dip being 15° at N. 58° W. It extends to the north-east until it is cut off by the continuation of the Croft's fault through Kirkland How, but is once more brought in on the north-east of the Arlecdon fault, forming a partial outlier from Rowrah Head by Ashby Banks and St. Michael's Church to Arlecdon.

It is also found near the top of Steel Brow, and between Blenkett Rigg and High Tutehill, and near Gilgarran.

The section at Barrowmouth shows the unconformity of the breccia to the underlying strata most distinctly, inasmuch as the surface of the Whitehaven sandstone is water-worn, and the lower bed of the breccia lies in and fills up those eroded hollows. This is still more marked between Barrowmouth and Egremont, where it overlaps Coal-measures, Grits, Carboniferous Limestone, and finally rests on Lower Silurians, east of the last-named place.

2nd, its composition.—The material of which this breccia is composed consists of small angular and subangular fragments of Carboniferous Limestone (in some instances partially dolomitized), quartzose sandstone, altered ashes, greenstone, clay-slate, vein quartz and syenite, imbedded in a limy and sandy matrix, and cemented by peroxide of iron, sometimes so firm and hard that the imbedded fragments will cut through along with the matrix in which they are enclosed when the rock is broken, in other cases so loose and friable that each individual fragment can easily be detached from the main mass. While it is generally made up of the rocks above mentioned, it varies from a breccia consisting of large angular pieces of Carboniferous Limestone, to that in which the contained rocks are clay-slate and altered ashes.

3rd, its formation.—Notwithstanding the angular and subangular character of the pebbles, there is much regularity in the stratification, and the distinct bedding shows that the materials must have been deposited in deep and still water; so that we cannot ascribe their formation to the transporting power of running water or

tidal waves and currents, for the continued action of these causes would have destroyed that distinctive characteristic, viz. the angular shape of the fragments, and the pebbles would have been rounded.

It is evident that we must seek for some other cause; and it seems to the author that the agency of ice will alone enable us to arrive at a probable solution of this question.

He is inclined to think that icebergs, as they parted and floated away from the glacier, would hardly deposit their burden of moraine matter in the quiet and gradual manner in which the materials composing this breccia must have been accumulated; besides, none of the fragments show any trace of ice-striæ, which might naturally have been expected to exist if this had been the means by which they were deposited.

In the seas of the Arctic region, the freezing of the water forms a sheet of ice along the shores. When thaw sets in, tons upon tons of rock débris, loosened by the frost, tumble down and collect on the ice-foot. The combined effects of heat and wind break up this floe-ice into immense sheets, which float away, and melting in the open sea, gradually deposit their load over the bed of the ocean.

Considering this fact in relation to the question now before us, we may be able to account not only for the angular fragments, but also for the stratified nature of this breccia, as well as the absence of ice-markings on these fragments. Thus the frosts of Permian times would freeze the water and waste the pre-existing rocks, and the loosened materials would accumulate on similar floe-ice; these floes, after breaking up, would float away and deposit their burden in tranquil water, giving rise to that regular bedding which is so characteristic of this breccia. Granting this to continue for a sufficient length of time, and we may easily account for the formation of a breccia from 90 to 100 feet thick, as in the present instance.

On the Jointed Prismatic Structure of the Giant's Causeway.
By Professor JAMES THOMSON, *F.R.S.E.*

On Geological Sections in the co. Down. *By* WILLIAM A. TRAILL, *M.A.I., F.R.G.S.I., of H.M. Geological Survey of Ireland.*

The author exhibited three sheets of geological sections, lately completed by him and published by the Geological Survey of Ireland, illustrating the geology of the co. Down and a small portion of the co. Antrim, accompanied by a geological map of the entire county on the scale of one inch to the mile (as published), having the different lines of sections laid down thereon. The sections themselves were drawn to the natural scale, and six inches to the mile.

Section I. ran from Annalong, about 7 miles south of Newcastle, across the Mourne Mountains, Slieve Donard (2796 feet high), to Slieve Croob (1755 feet high), thence N.W. by Moira to Derrymore Point on Lough Neagh.

Section II. from Narrow-water near Warrenpoint, E.N.E., across the Mourne Mountains and Slieve Donard to Newcastle.

Section III. from Soldier's Point, at the entrance, to Carlingford Lough, N.N.E., across the Mourne Mountains to Newcastle.

Section IV. from Killinchy on the west side of Strangford Lough, N. by Castle Espie and Scrabo Hill to near Holywood on Belfast Lough.

The author gave a brief sketch of the geology of the entire co. Down, with the probable order of succession of the different rocks composing it, having representatives of both the older and the newer formations, and igneous rocks of very different ages.

The county for the most part consisted of Lower Silurian rocks, extending from the Copelands to Carlingford Lough, being part of the large Silurian tract stretching into the south of Scotland, and belonging chiefly to the "Caradoc" or "Bala" beds, while the Llandeilo beds occur in some places, though a line of demarcation between them had not been determined.

These beds have been thrown into a number of large flexures, minor contortions, and crumplings, as represented in many places on the sections.

Contemporaneous with these beds are a number of felspathic ashes, interbedded felstones, and intrusive felspathic and minette dykes; these, for the most part, occur along the lines of bedding and are inclined and contorted with them. They are mostly to be found in the Portaferry and Downpatrick districts*.

After these there seems to come the Granite of Slieve Croob, by some thought to be of metamorphic origin, and being probably of Palæozoic age†.

Subsequent to this Granite, or at any rate after the great contorting up of the Silurian beds, there occur a large number of dykes, melaphyres, dolerites, and diabase, penetrating those contorted beds, mostly in vertical dykes, and which are of an age anterior to the Mourne Granite. Of these, the chief source seems to have been towards the south of the county; and many of the old pipes or vents are still to be found, as on Slieve Moughanmore, Leckanmore, and Slieve Martin†.

The Carboniferous rocks seem to follow next; but the remains of them are only to be found in three localities, viz. at Soldier's Point, at Castle Espie, and at Holywood. They probably extended over a large portion of the county, but have suffered great denudation, and these isolated patches alone remain. Whether the Coal-measures did exist over the Lower Limestone here, as most probably they did, we have now no trace of them whatever remaining, they have been entirely swept away; and this denudation seems to have been carried on till the Silurian rock was laid bare over most of this district.

Here may be mentioned the occurrence of the Permian beds in two localities, but each of very small extent, viz. near Cultra on the shore of Belfast Lough, and identified by the presence of such fossils as *Bakewellia antiqua*, *Schizodus Schlotheimi*, *Productus horridus*, and *Turbo helicinus*; these beds rest directly and unconformably upon the Lower Limestone*.

The other locality is about 2½ miles S.E. of Moira, where a small patch of breccia and earthy magnesian limestone occurs, resting directly on Silurian beds*.

Next seems to occur the Granite of the Mourne Mountains, in its fullest and widest sense an eruptive Granite, carrying up the Silurian beds with it, and cutting off the older melaphyric dykes at the junction, as is so well seen in many places, especially on Slieve Muck†.

Subsequent to this Granite, there are two distinct sets of igneous rocks penetrating it and the Silurian beds adjacent, with their older dykes. These may be classed as quartziferous porphyries and felstones (basic), as found on Slieve Meelmore and Slieve Bearnagh. And last of all some basalt dykes, which are supposed to be of Tertiary age.

The author then described in detail the several sections, pointing out the relationships between the different formations and the different igneous dykes penetrating them.

Referring more minutely to the Scrabo-Hill section, as having a special and more local interest, on account of their recent search for coal in that neighbourhood, he described the upward passage from the Silurian beds near Killinchy to the Carboniferous or Lower Limestone and Limestone Shale at Castle Espie, where the limestone is largely worked and burned in a Hoffman's kiln, at the works of Samuel Murland, Esq., a thickness of 45 feet being attained by the limestone in the quarries. This limestone extends for about 1¼ mile towards Comber, but is covered with a thick head of Drift. It dips northward under the New Red Sandstone formation, which in this part of the county comes in and forms the flanks of Scrabo Hill, filling up the old valley of denudation extending from Strangford Lough to Belfast Lough. The section showed the succession of beds through the Bunter Sandstones, Waterstones, and Keuper Sandstones, to the cap of dolerite forming the top of the hill, with an elevation of 540 feet. This dolerite or hypersthene rock may be associated with the basaltic plateau of the co. Antrim, possibly as an outlier, or a separate pipe may exist somewhere to the westward of the summit.

This trap penetrates the New Red Sandstone beds in horizontal sheets and in

* Detailed accounts to be found in the memoirs of the Geological Survey of Ireland.

† *Vide* "Granitic, Plutonic, and Volcanic Rocks of the Mourne Mountains and Slieve Croob," Report Brit. Assoc. 1871, Trans. Sect. p. 101.

vertical dykes; some of which dykes lead up through the cap itself, possibly to higher flows, which have since been denuded away. These are all well seen in a number of quarries which have been opened along the sides of the hill; which show, however, that the Sandstone beds have not been displaced, except near the margin of the dolerite.

Passing over the top of Scrabo Hill, the same succession of beds are met with, down to the Silurian rocks, occupying the high ground between it and Belfast Lough; and at Cultra near Holywood the Lower Limestone, the Permian, and the Bunter beds are again crossed over.

In conclusion, the author referred to the question whether coal will be found in the neighbourhood of Newtownards or Scrabo Hill, where borings had been carried on for some time past.

From the one-inch map it was shown that the New Red Sandstone, along almost its entire margin, rested directly on the Silurian beds, at Castle Espie on the Lower Limestone, and that at Cultra the Permian beds rested directly on the Lower Limestone.

Now is it the least probable that if the Coal-measures did exist hereabouts that we should have been unable to find any trace of their outcrop along this entire line of junction of the New Red Sandstone and underlying rocks? Though they probably may have existed, they all disappeared with the great denudation which took place before the deposition of the New Red Sandstone. Another evidence against the presence of the Coal-measures is, that the Permian beds near Moira rest directly on the Silurian rocks.

Additional evidence is to be found in the borings which were made towards the end of the last century in this district; and in every case where the New Red Sandstone was pierced through, the Silurian rocks were met with; some of these borings were made to a depth of 240 feet.

Of the borings lately made in this district, none were carried sufficiently deep to prove what existed underneath. It is to be regretted that one, sunk at Cherry valley, north of Castle Espie, was stopped at a depth of about 120 feet, without penetrating the New Red Sandstone, as the author considered that within 20 or 30 feet more the underlying rock would have been entered, and proved whether the limestone extended even that far to the northward under the New Red Sandstone, to which distance he hardly thought it did.

From these and numerous other considerations the author believed that now no Coal-measures exist in this locality, and that he was justified in excluding them from a position on the geological section across Scrabo Hall, and that thus the co. Down was deprived of the hope of obtaining coal.

Physics of the Internal Earth. By Dr. Vaughan.

On the Discovery of Microzoa in the Chalk-flints of the North of Ireland. By Joseph Wright, *F.G.S.*

In consequence of the extreme hardness of the Irish chalk (White Limestone) geologists until quite recently had failed to find in these beds any of those Microzoa which occur so abundantly in rocks of the same age in England. In 1872 the author discovered that the soft powdery material frequently found inside the cavities that are so often met with in flint, on being washed and cleaned, yielded Foraminifera, Ostracoda, and sponge-spicula in abundance, this powder being, in fact, a portion of the old sea-bottom of the Cretaceous times. The flints when newly quarried are usually hard and compact throughout, and it requires exposure to the action of the weather to change the limestone frequently occurring into the powdery material.

Nearly all the Foraminifera and Ostracoda examined chemically by the author are siliceous; in a few instances the interior casts of the Foraminifera have alone been changed, the shell having remained calcareous. He has since examined personally a large portion of the chalk-area of the north of Ireland, and has seen examples of chalk powder from 35 different localities in the counties of Antrim, London-

derry, and Down; and among the many specimens collected from these various stations has recognized, besides corals and Polyzoa, 69 species of Foraminifera, 11 species of Ostracoda, and 33 forms of sponge-spicula; many of these attain fine proportions, being much larger than those usually obtained from the washings of English chalk. Having found that the "Paramoudras" as well as the ordinary flints usually contain sponge-spicula in quantity, he has been led to consider that flints in most instances have originated in a sponge or some other organism round which the silica accumulated according to well-known chemical laws. The Foraminifera are very numerous both in individuals and species; the following genera are well represented:—*Trochammina, Lituola, Lagena, Nodosaria, Dentalina, Frondicularia, Flabellina, Pleurostomella, Lingulina, Marginulina, Vaginulina, Planularia, Cristellaria, Polymorphina, Globigerina, Pullenia, Rhabdogonium, Textularia, Gaudryina, Virgulina, Verneuilina, Bulimina, Bolovinia, Planorbulina, Truncatulina, Pulvinulina, Rotalia.*

BIOLOGY.

Address by Professor PETER REDFERN, *M.D., President of the Section.*

I CONSENTED to allow myself to be nominated President of this Section in compliance with the kindly expressed wishes of scientific friends, notwithstanding that I felt that the duties of the Chair would have been more fitly discharged by many who have attended the Meetings of the Association more regularly and laboured to promote its objects more continuously than I have been able to do.

Fortunately the increasing importance and the vast extent of the subjects comprised under the head of Biology have led to a division of the business of this Section into the separate departments of Anatomy and Physiology, Botany and Zoology, and Anthropology; and it is a great relief to me that the departments of Botany and Zoology and of Anthropology, respectively, will be presided over by gentlemen of the highest eminence in those subjects, and that Anatomy and Physiology, in which I am more immediately interested, will alone come under my direct supervision. It has occurred to me that, in attempting to give a stronger impulse and a more systematic direction to scientific inquiry, the time ordinarily devoted to an introductory address could not be more profitably occupied than by bringing into as great prominence as possible some of the great revolutions in our knowledge of Anatomy and Physiology which have taken place in my own time and under my own immediate observation.

I remember, as if it were yesterday, the elucidation in the Museum of the Royal College of Surgeons of Edinburgh of the newly discovered cell-theory by the late distinguished Professor of Anatomy in Edinburgh, John Goodsir—his account of the production of ulceration by cell-growth, of the characters of the corpuscles of bone, of the structure of lymphatic glands, and of the germinal centres of basement membranes as they were then understood. This was the time when the teaching of Histology was first established in Great Britain. Two students, of whom I was one, formed the first class under the most enthusiastic of teachers, my old friend Dr. Hughes Bennett. The University of Edinburgh had just passed through what was probably the most brilliant period in its history. The race of the last of the Munros was well nigh run; the great discoverer of the difference in the motor and sensory nerves, Sir Charles Bell, was still living; the aristocracy of Scotland had only just ceased to crowd the class-room and witness the brilliant and successful experiments of Dr. Hope. The day of Cullen, of Home, and Duncan, and Macintosh was over; but there still remained in the University the most loved and revered of teachers, the benevolent Dr. Alison, Sir Robert Christison, Sir George Ballinghall, and Mr. Syme, Dr. Abercrombie still practising his profession in the city.

At this period the great discoveries of Schleiden and Schwann seemed likely to upset all that had previously constituted Physiology. The idea that all tissues

were either composed of cells or had been formed of cells—that nucleated cells elaborated all the secretions and formed the excretions—that their energy lay at the very root of the formation, the reproduction, and the function of every tissue and organ, was a revelation of such astounding simplicity as might well upset men's minds and prevent their seeing beyond.

No one who did not live through that time will, I believe, ever realize the eagerness and anxiety with which every new statement of the action of cells was received and added to the previous knowledge of their amazing power—or, on the the other hand, be able to judge of the feeling half akin to disappointment which was experienced as each succeeding attack was made on this charming theory, showing it to be really human, very human indeed.

Cells were then understood to constitute the mass of all organs (the liver, spleen, kidney, and brain), and to be the main agents in the discharge of their functions—to exist and grow upon the definite membranous walls of the glandular vesicles and ducts—to be fed by blood brought to the attached surface of membranes which seemed almost everywhere to form an absolute separation of the cellular part (the potential gland) from the non-essential blood- and lymph-vessels, the nerves, and framework of the organ. It seemed almost a pity that these little microscopic deities should be hampered by the necessities of their own existence, that they should need such base things as blood-vessels, nerves, and packing materials. Now how strangely are matters changed! What if it should turn out that these apparently independent little beings are not independent at all—that they are only the dilated endings of nerves. To this subject I shall refer again by-and-by.

This great cell-theory has now given place to what I think is certain knowledge, that living matter may move, perform all the functions of assimilation and nutrition, and reproduce its like without having any of the essential characters of a cell. A living mass of protoplasm may change its shape, alter its position, feed and nourish itself, and form other matter having the same properties as it has and yet be perfectly devoid of any structure recognizable by the highest powers of the microscope.

Mr. Lister showed that the contraction of pigment-cells in the skin changes the position of the pigment-granules, driving them alternately into the processes and the body of the cell. Kühne, Golubew, and Stricker observed changes of form in amœbæ (white blood-corpuscles and embryonal capillaries, respectively) after the application of electrical stimuli; and Brücke observed contraction in the pigment-cells of the skin of the chameleon after excitation of the sensory nerves; whilst Kühne noticed contraction in corneal cells after excitation of the corneal nerves.

Thus obvious movements in fixed cells or masses of protoplasm are proved to result from the operation of various stimuli, including nervous stimuli.

But all cells are not fixed. The blood-cells, fixed, as cells of organs, at an early period, become free in the blood-fluid and are moved along by the forces which circulate it until a second time they enter into the composition of the solid tissues by penetrating the walls of the blood-vessels and moving along the substance of the tissues for purposes which are not yet wholly explicable.

What naturalist will not at once suggest how frequently this process of alternate fixation and movement of animal forms occurs low down in the scale? and yet how startling is it in man! how impossible to reconcile with our former ideas of the existence of membranous coverings, of cells, surfaces, and of gland-ducts! But, with or without explanation, the facts must be recognized; the floating blood-cells are really the very cells which once formed the substance of the lymphatic glands, the spleen, and other organs; and they do, in fact, move through the walls of the blood-passages, and wander about freely in what we call solid tissues.

Our knowledge of this circulating fluid has marvellously increased. The duration of the life of any of its particles is but short; they die and their places are occupied by others, as was the case with our forefathers, and will be the case with ourselves. It is now a matter of observation, which commenced with Hirt of Zittau, that after every meal an amazing number of white corpuscles are added to the blood: breakfast doubles their proportion to the coloured corpuscles in half an hour; supper increases their proportion three times; and dinner makes it four times as great. They come from such solid glands as the spleen. In the blood going to the spleen, their proportion is one to two thousand two hundred and sixty; in that returning

from the spleen it is one to sixty. Every organ and every tissue changes this fluid; and, to my mind, perhaps the most stupendous miracle of organization is the steady maintenance of but slightly variable characters in the living and moving blood, which is every moment undergoing changes of different kinds as it circulates through each tissue and organ in the body.

Yet with all this change there is an invariable transmission of the parental characters by continual descent from particle to particle as each takes the place of a former one; and thus each organ continues to discharge the same function from year to year. Animals of the same kind retain the old number of organs, the same shape of body, and similar modes of life. There is no sign of commencing life, no coining of new vital power, no production of living out of dead matter. The original life extends its limits; it operates in a more extended sphere; but it is the same life, it operates in the same way, it never fails to be recognizable in the individual by the same characters as it had when it was first known. Whatever other functions it discharges, it acts continually in obedience to the first great law; it increases and multiplies and replenishes the earth.

Let us now for a few moments compare our former views of the structure of animal membranes with the present ones. The skin (covering the outer surface of the body), the mucous membranes, the serous linings of the great internal cavities and of the blood- and lymph-vessels, and the lining membranes of joints were all alike viewed as if formed of a definite membrane covered on one side by cells, and on the other supplied by blood- and lymph-vessels and by nerves—the membrane covering in the latter parts and effecting an absolute separation of the cells from the vessels and nerves, which were universally believed never to penetrate into the cellular layer. The cells were regarded as the parts actively engaged in the performance of the functions, the vessels and nerves aiding thereto supplying materials to be acted on by the cells, and the nerves regulating the amount of action at particular times for special purposes. The diseased conditions, like the functions, were kept perfectly distinct; and we had one set of diseases of the epithelial or cellular parts, and another and a different set of diseases of the membranes and of the parts below.

I think the first occasion on which the public faith in these views was seriously shaken was when the late distinguished Professor of Medicine in St. Andrews, Dr. John Reid, died of what was called an epithelial cancer of the tongue. Microscopical examinations showed that the disease existed in the cellular covering of the tongue. A sufficient cause for it was supposed to exist in the irritation caused by sharp points of the teeth, to cover which a protecting silver plate was constructed. The diseased parts were removed with the greatest skill and care by Sir William Fergusson, and subsequently by the late Dr. James Duncan, assisted by Mr. Goodsir and Mr. Spence, now Professor of Surgery in the University of Edinburgh. Every conceivable care was taken by these attached friends of the poor sufferer to remove every trace of the disease; but it progressed steadily and destroyed this valuable life.

At this period no one could understand the extension of an epithelial disease through a basement membrane; and therefore the affection of the adjacent lymphatic glands was explained by supposing the diseased action to have been propagated from cell to cell along the epithelial surface of the lymphatic vessels.

Not long afterwards the sternly truthful and accurate Sir James Paget declared, in terms of terrible significance to the sufferers from this disease, that epithelial cancer takes a little longer time than ordinary cancer to do its fatal work.

And it soon became thoroughly well known that the glands of the skin, the hair-bulbs, and the teeth are produced by a local development of the deep cells of the cuticle, extending far below the line of the basement membrane or cutis, and through the position which it was supposed to occupy, as though no membrane were there to hinder them.

Thus the basement membrane which was supposed so arbitrarily to separate the cells on one surface of membranes from the vessels and nerves on the other, gives way at once before an increased development of the cells, whether in the formation of new organs or the extension of disease. And the membranous walls of capillary blood-vessels allow the corpuscles of the blood to pass through them much in the

same way as solid particles enter into and traverse the substance of the protoplasm of an amœba or other mass of sarcode.

Whilst physiologists were engaged in these observations, the late Master of the Mint, Mr. Graham, was conducting a series of experiments of the most remarkable kind, and of the utmost importance to physiology, as well as to chemistry and physics. He found it necessary to separate two sets of substances as crystalloids and colloids,—the colloids being penetrable by the crystalloids as readily as water, the crystalloids (such as hydrochloric acid and common salt) passing through organic membranes with great freedom, whilst many of the colloids, such as albumen and gum, will not penetrate them at all. This discovery has enabled the chemist to separate crystalloids from colloids by dialysis, even when they occur in the most minute proportions—for instance, to separate 80 or 90 per cent. of a ten-thousandth part of arsenious acid in twenty-four hours from porter, milk, or infusions of viscera, substances notoriously difficult to analyze. And it has enabled physiologists to explain how animal membranes are traversed by various substances which could not pass through them without being changed from the colloidal into the crystalloidal form. Thus the colloidal starch and albumen of our food scarcely admit of absorption until in the process of digestion the starch becomes sugar and the albumen albuminose, crystalloidal bodies which pass through animal membranes with great facility. And again, this crystalloidal albuminose, after having passed into the tissues through the membranous walls of the vessels, may become a second time a colloid, and be deposited and fixed as tissue-substance, ready in its turn to be permeated by crystalloids either for temporary or more durable purposes in the economy.

The effect of this great discovery of Mr. Graham's shows how impossible is the advance of physiology without a corresponding advance in our knowledge of chemistry and physics.

If basement membranes, the walls of blood-vessels, and of cells are made up of colloidal matter, we can easily understand how they are penetrated by crystalloids; and in like manner it is perfectly possible that they may be traversed by other substances in solid forms—as, for instance, the walls of blood-vessels by the corpuscles of the blood. No wonder that there is a continual deposition and removal of the constituents of the tissues, if so slight a change as that from the crystalloidal to the colloidal form, and the reverse, makes such perfectly marvellous differences in the relations of these substances to each other.

We must look upon the tissues of an animal body as we do upon the substance of an amœba, and recollect how penetrable the surfaces and tissues of animals are; then we shall cease to be startled when we see these parts become the seat of entirely new deposits, or find them traversed by migrating blood-corpuscles as freely as a colloid is penetrated by a crystalloid.

It is impossible to foresee what may be the result to physiology of this great advance in our knowledge of the varying relations of substances to each other according as they present themselves at different times in the opposite physical conditions which were described by Mr. Graham as crystalloidal and colloidal. But it is plain that we cannot continue to look upon animal membranes as forming such decided barriers against the penetration of one tissue by another, or by foreign matters, as was once supposed.

Let me now direct your attention to the present aspect of the question how far basement membranes limit the distribution of vessels and nerves and separate them from the cells of glands and membranes.

Mr. Bowman, in his admirable researches into the anatomy of the organs of sense, discovered that the filaments of the nerves of smell have a remarkable structure—that they are nucleated, finely granular, contain no white substance of Schwann, and resemble the gelatinous nerve-fibres. The epithelial surface, too, of the olfactory region Mr. Bowman described as differing greatly from that of the adjacent parts of the nasal mucous membrane, and as being of a dark sepia tint. Subsequent examinations by Hoyer, Max Schultze, and Lockhart Clarke confirmed these statements; and those of Schultze demonstrated that the cells are of two kinds:—one elongated and filled with yellowish granular protoplasm, exposed at the outer end of each cell, and containing a clear oval nucleus in clear protoplasm in its

deeper part, which is first attenuated and then expanded into a broad flattened process, apparently connected with the connective tissue; the other cell, the proper olfactory cell, a thin, fibrous, rod-like body, is moniliform or varicose, connected below with the out-runners of a nerve-cell, and in birds and amphibia furnished with one or more hair-like processes, which at the free end come directly into contact with odorous particles. Exner in 1872 denied the distinctness of these two forms of cells, stating that there are all intermediate forms, and that both forms are connected with a deep network continuous with filaments of the olfactory nerve. But Dr. Newell Martin, in a paper published in the November Number of the 'Journal of Anatomy and Physiology,' maintains that the two kinds of cell are distinct, though their characters approximate very closely in the instance of the frog. He inclines to the belief that, as both forms of cell are so distinct from ordinary epithelium, they are all olfactory cells.

The only conclusion which can be drawn from these observations is that in this situation the olfactory nerves divide into myriads of small finger-like processes, which, exposed on the free surface of the membrane, are actually engaged in feeling at the odorous particles to inform us of their characters.

This single instance, so thoroughly proved, would be sufficient to destroy our former ideas that nerves are spread out under basement membranes and never penetrate an epithelial layer.

But this is not the only case of the kind. The general relations of the gustatory nerves to the epithelial cells of the tongue have been described by Axel Key as similar in the fungiform papillæ of the frog, and by Schwalbe and Lovén in the gustatory cells of the circumvallate and of some of the fungiform papillæ in men and animals. On the protected sides of the circumvallate papillæ a peculiarity in the shape and arrangement of the epithelial cells produces a series of taste-cones, the central cells of which are furnished with hair-like prolongations similar to those of the olfactory cells.

In the otolith-sacs and the ampullæ of the semicircular canals of the ear, the nerve-filaments, having lost their white substance, become connected with peculiar auditory cells and end in hair-like processes between the epithelial cells. In the cochlea, too, notwithstanding the complication of the examination produced by the rods of Corti, there is reason to believe that the cells supporting hairs which project beyond the epithelial surface are connected with the primitive nerve-fibrils of the plexus below.

Of the recorded instances in which nerves pass through basement membranes to get into direct contact or continuity with the superjacent epithelial cells, none is so striking as that of the salivary and other glands, if there be the least ground for the remarkably detailed observations and suggestions of Pflüger. They are of so much importance and interest in connexion with the whole process of secretion, that I offer no excuse for directing your attention to them, even though it may be proved that the act of secretion is not attended with such marvellous and extensive changes of structure as Pflüger supposes. Up to a certain point his observations may be easily and abundantly confirmed; beyond that there is much greater difficulty; but this Meeting offers one of the most favourable opportunities for extending our knowledge by bringing different observers into easy communication with each other, and enabling each to help the rest by stating the means by which he had overcome what seemed at first to be insuperable difficulties in the progress of an investigation.

Pflüger calls attention to the very variable characters of the alveoli, the secreting cells, and the excretory ducts of the salivary glands. These parts, which were believed to have very determinate sizes and characters, he declares to differ very greatly in different parts of the same gland. The alveoli, occupied by what we understand as secreting or glandular epithelial cells, and the excretory ducts, lined by columnar epithelium, he thinks he can prove to be but different stages of development of the same structures, produced on the ends of the myriad nervous filaments supplied to these glands.

On this view glandular epithelial cells must be regarded as special organs of termination of nerve-fibrils, like the auditory cells, touch-corpuscles, olfactory cells, muscular fibre-cells, and the like—the relation between such structures and the

nerves becoming so close that it may be difficult, perhaps impossible, to define their respective limits. Pflüger has figured the nuclei of the cells of the alveoli of the salivary glands, the salivary cells, connected with a delicate fibre, which often pierces the surface of the cell in contact with the membrana propria, and gives the cell the appearance of being stalked. This appearance has also been seen by Schlüter, Otto Weber, Gianuzzi, Boll, and Kölliker; and, indeed, the appearance which Pflüger has figured may be seen by any one who will take the trouble to examine the salivary glands of the common cockroach (*Blatta orientalis*). This process was shown to me by my friend and pupil, Mr. Charles Workman; and I have several preparations which show a similar process to that which Pflüger has observed and figured; but that it is as clearly connected with the nucleus of the cell as he describes it I am not prepared to affirm. Pflüger says it is hollow, and often discharges a large quantity of tenacious material which clearly proceeds from the nucleus.

In the interior of the gland there are ducts lined with a thick but single layer of columnar epithelium, the cells of which are clear and nucleated near their free end, but furnished with a large number of extremely fine varicose hairs at the end connected with the membrana propria. This epithelium becomes thicker as the ducts proceed towards their connexion with the alveoli; and as transparent drops can be seen transuding from the ends of the cells when saliva has been made to flow by irritation of the gland, Pflüger concludes that they are important secretory organs. Such ducts frequently form loops, or bend suddenly, or possess diverticula. The epithelium of the ducts, which carry the secretion out of the gland, is of a different and apparently less important kind.

Pflüger directs special attention to the great number of nerves connected with the alveoli. He has identified them in fresh specimens by their investment here and there by an ordinary double-contoured medulla, by their being blackened by perosmic acid, by their varicosities, and by tracing them to larger and more easily recognizable nerves. He finds them branching in great numbers amongst the cells of the alveoli, and traces their fibrils to the nuclei of the cells, sometimes after they have been connected with multipolar ganglion-cells. Or nerves covered by medulla and sheath, and containing numerous varicose axis cylinders, branch, enlarge, and become covered with protoplasm set with nuclei, forming what Pflüger calls a protoplasmic foot, and supposes to be a structure intermediate in character between nervous and glandular tissue. And on the surface of the ducts lined by columnar epithelium a nerve divides into a pencil-like tuft of varicose fibrils, each of which Pflüger says is directly continuous with one of the processes of a columnar epithelial cell. I have frequently seen the pencil-like tuft of varicose fibrils on the surface of the ducts lined by columnar epithelium; but it is not so easy to be sure that the fibrils are connected with the processes of the cells. However, the statement is made in the most positive way by Pflüger, who has made these glands the subjects of very special and lengthened investigation; and his drawings afford very strong corroborative testimony of the value of his statements. Moreover, in independent observations on the pancreas, he has also traced the nerves to endings in the secreting cells.

But Pflüger has gone greatly further than this. He has figured the hair-like processes at the attached end of the columnar cells in all stages of transition into salivary cells of new alveoli; and having previously found the nerves connected by varicose fibrils with protoplasmic masses set with nuclei, he concludes that it is possible that the salivary cells are developed on the ends of the nerves without interference of their own nuclei, and that, as a continual new formation of alveoli and salivary cells implies the atrophy and disintegration of corresponding older parts, the alveoli with pale offshoots of various forms which he has seen in moles are evidences of such atrophy.

With these numerous instances in which nerves are alleged to pass through membranes to be connected with the cells on their surfaces, as if these were their special modes of termination, we might well be content until there has been time for further investigation by independent observers. But there are yet other instances. Langerhans described, in 1868, a fine network of fibres in the skin, from the superficial part of which fine non-medullated fibres pass out of the cutis and

end in the Malpighian layer of the epidermis. He saw in the epidermis also well-marked cells which gave off several processes towards the horny layer, and one long slender process which passed through the Malpighian layer into the cutis. He considers these cells to be nervous, and their peripheral processes to be the terminal parts of the nerves of the skin. C. J. Eberth agrees in the main with Langerhans, and recognizes fine nerve-fibres passing from the nerves of the cutis into the deeper layer of cuticular cells, and also star-and-spindle-shaped cells in the cuticle, which he suggests may be nervous structures, though he has not traced them in connexion with nerve-fibres.

On the surface of young fishes and Amphibia F. E. Schutze has described nerve-hairs arranged in the form of tufts or brushes very much as is the case in the organ of hearing; in this instance the brush-like endings of the nerves are probably connected with touch.

Cohnheim has described the corneal nerves as forming a superficial plexus under the anterior elastic lamina; from this perforating branches pass perpendicularly through the lamina, and then, under the epithelium, break up into brush-like or star-shaped finer branches, which form a plexus giving off fine nerves at tolerably regular intervals between the deep columnar cells and the more superficial spheroidal ones, and dividing at length into their finest branches, which end by somewhat swollen extremities in the most superficial epithelial layers. Thus the exquisite sensibility of the front of the eye, like that of the olfactory or gustatory mucous membranes, may be accounted for.

When I look upon the vast amount of research which has been applied to this department of Biology for some years past, and think that the instrument which has afforded the great means for it was only perfected so as to be capable of use for such purposes about 1820, I cannot but congratulate the Section on the abundant fruits we are reaping.

And when, in addition, I contemplate the amount of certainty which physical science has imparted to physiology by furnishing the means of examining and accurately measuring the rates of transmission of nerve-currents, of obtaining tracings of the respiratory movements and of the arterial pulsations, of examining the retina in the living eye and the larynx of a living man almost as readily as if these parts were exposed in a dissection, I cannot but conclude that this nineteenth century has been already distinguished as a very notable one for Biology, and especially for Physiology.

Considering that so much time is required for making a single careful observation, it is very fortunate that so large an array of inquirers and so much talent are employed upon the subjects in which we are interested, and that once a year we have this admirable opportunity of listening to the results of inquiries instituted by the most eminent men in all parts of the world, and of hearing different views advocated with the greatest earnestness and yet with perfect good humour, and a rigorous determination to rest satisfied with nothing but the truth.

Botany and Zoology.

Address to the Department of Botany and Zoology. *By* Dr. Hooker, *C.B., D.C.L., Pres. R.S.*

I have chosen for the subject of my Address to you from the chair to which the Council of the British Association has done me the honour of calling me, the carnivorous habits of some of our brother organisms—plants.

Various observers have described with more or less accuracy the habits of such vegetable sportsmen as the Sundew, the Venus's fly-trap, and the Pitcher-plants, but few have inquired into their motives; and the views of those who have most accurately appreciated them have not met with that general acceptance which they deserved.

Quite recently the subject has acquired a new interest, from the researches of Mr. Darwin into the phenomena which accompany the placing of albuminous sub-

stances on the leaves of *Drosera* and *Pinguicula*, and which, as Dr. Burdon Sanderson has remarked, prove in the case of *Dionæa* that this plant digests exactly the same substances, and in exactly the same way, that the human stomach does*. With these researches Mr. Darwin is still actively engaged; and it has been with the view of rendering him such aid as my position and opportunities at Kew afforded me, that I have, under his instructions, examined some other carnivorous plants.

In the course of my inquiries I have been led to look into the early history of the whole subject, which I find to be so little known and so interesting that I have thought that a sketch of it, up to the date of Mr. Darwin's investigations, might prove acceptable to the members of this Association. In drawing it up, I have been obliged to limit myself to the most important plants; and with regard to such of these as Mr. Darwin has studied, I leave it to him to announce the discoveries which, with his usual frankness, he has communicated to me and to other friends; whilst with regard to those which I have myself studied (*Sarracenia* and *Nepenthes*) I shall briefly detail such of my observations and experiments as seem to be the most suggestive.

Dionæa.

About 1768 Ellis, a well-known English naturalist, sent to Linnæus a drawing of a plant, to which he gave the poetical name of *Dionæa*. "In the year 1765," he writes, "our late worthy friend, Mr. Peter Collinson, sent me a dried specimen of this curious plant, which he had received from Mr. John Bartram, of Philadelphia, botanist to the late King"†. Ellis flowered the plant in his chambers, having obtained living specimens from America. I will read the account which he gave of it to Linnæus, and which moved the great naturalist to declare that, though he had seen and examined no small number of plants, he had never met with so wonderful a phenomenon ‡:—

"The plant, of which I now enclose you an exact figure with a specimen of its leaves and blossoms, shows that Nature may have some views towards its nourishment, in forming the upper joint of its leaf like a machine to catch food: upon the middle of this lies the bait for the unhappy insect that becomes its prey. Many minute red glands that cover its surface, and which perhaps discharge sweet liquor, tempt the poor animal to taste them; and the instant these tender parts are irritated by its feet, the two lobes rise up, grasp it fast, lock the rows of spines together, and squeeze it to death. And further, lest the strong efforts for life in the creature just taken should serve to disengage it, three small erect spines are fixed near the middle of each lobe, among the glands, that effectually put an end to all its struggles. Nor do the lobes ever open again, while the dead animal continues there. But it is nevertheless certain, that the plant cannot distinguish an animal from a vegetable or mineral substance; for if we introduce a straw or pin between the lobes, it will grasp it full as fast as if it was an insect"§.

This account, which in its way is scarcely less horrible than the descriptions of those mediæval statues which opened to embrace and stab their victims, is substantially correct, but erroneous in some particulars. I prefer, however, to trace out our knowledge of the facts in historical order, because it is extremely important to realize in so doing how much our appreciation of tolerably simple matters may be influenced by the prepossessions that occupy our mind.

We have a striking illustration of this in the statement published by Linnæus a few years afterwards. All the facts which I have detailed to you were in his possession; yet he was evidently unable to bring himself to believe that Nature intended the plant (to use Ellis's words) "to receive some nourishment from the animals it seizes;" and he accordingly declared that as soon as the insects ceased to struggle, the leaf opened and let them go ||. He only saw in these wonderful actions an extreme case of sensitiveness in the leaves, which caused them to fold up

* 'Nature,' June 11, 1874, p. 107.

† A Botanical Description of the *Dionæa muscipula*......in a letter to Sir Charles Linnæus, p. 38.

‡ Smith's 'Correspondence of Linnæus,' vol. i. p. 235.

§ Ellis, *l. c.* p. 37.

|| "Usque dum lassum quiescat, tumque dimittunt."—Mantissa altera (1771), p. 238.

when irritated, just as the sensitive plant does; and he consequently regarded the capture of the disturbing insect as something merely accidental, and of no importance to the plant. He was, however, too sagacious to accept Ellis's sensational account of the *coup de grâce* which the insects received from the three stiff hairs in the centre of each lobe of the leaf. Linnæus's authority overbore criticism, if any were offered; and his statements about the behaviour of the leaves were faithfully copied from book to book.

Broussonet (in 1784) attempted to explain the contraction of the leaves by supposing that the captured insect pricked them, and so let out the fluid which previously kept them turgid and expanded *.

Dr. Darwin (1791) was contented to suppose that the *Dionæa* surrounded itself with insect-traps to prevent depredations upon its flowers †.

Sixty years after Linnæus wrote, however, an able botanist, the Rev. Dr. Curtis (dead but a few years since), resided at Wilmington, in North Carolina, the headquarters of this very local plant. In 1834 he published an account of it in the 'Boston Journal of Natural History' ‡, which is a model of accurate scientific observation. This is what he said:—"Each side of the leaf is a little concave on the inner side, where are placed three delicate hair-like organs, in such an order that an insect can hardly traverse it without interfering with one of them, when the two sides suddenly collapse and enclose the prey, with a force surpassing an insect's efforts to escape. The fringe of hairs on the opposite sides of a leaf interlace, like the fingers of two hands clasped together. The sensitiveness resides only in these hair-like processes on the inside, as the leaf may be touched or pressed in any other part without sensible effects. The little prisoner is not crushed and suddenly destroyed, as is sometimes supposed, for I have often liberated captive flies and spiders, which sped away as fast as fear or joy could carry them. At other times I have found them enveloped in a fluid of a mucilaginous consistence, which seems to act as a solvent, the insects being more or less consumed in it."

To Ellis belongs the credit of divining the purpose of the capture of insects by the *Dionæa*. But Curtis, besides making out the details of the mechanism, by ascertaining the seat of the sensitiveness in the leaves, also pointed out that the secretion was not a lure exuded before the capture, but a true digestive fluid poured out, like our own gastric juice, after the ingestion of food §.

For another generation the history of this wonderful plant stood still; but in 1868 an American botanist, Mr. Canby, who is happily still engaged in botanical research, while staying in the *Dionæa*-district, studied the habits of the plant pretty carefully, especially the points which Dr. Curtis had observed. His first idea was that "the leaf had the power of dissolving animal matter, which was then allowed to flow along the somewhat trough-like petiole to the root, thus furnishing the plant with highly nitrogenous food." By feeding the leaves with small pieces of beef, he found, however, that this was not so, but that these were completely dissolved and absorbed; the leaf opening again with a dry surface, and ready for another meal, though with an appetite somewhat jaded. He found that cheese disagreed horribly with the leaves, turning them black, and finally killing them. Finally, he details the useless struggles of a *Curculio* to escape, as thoroughly establishing the fact that the fluid already mentioned is actually secreted, and is not the result of the decomposition of the substance which the leaf has seized.

* Mém. de l'Acad. des Sc. 1784, p. 614. † Botanic Garden, pt. ii. p. 15.

‡ Vol. i. pp. 123–125.

§ I am indebted to Mr. Warner, of Winchester, for pointing out to me that the seat of sensitiveness in the leaves of *Dionæa* was discovered thirty years earlier than this by Sydenham Edwards, the botanical draughtsman. The fact is stated (1804) in the description of plate 785 in the twentieth volume of the 'Botanical Magazine,' then edited by Dr. Curtis's English namesake. I quote Curtis's remarks:—"These small spines are mentioned and figured by Ellis, and supposed by him to assist in destroying the entrapped animal; but that they are the only irritable points, and that any other part of the leaf may be touched with impunity, was discovered by our draughtsman, Mr. Edwards, several years ago, when taking a sketch of the plant flowering at Mr. Liptrap's, Mile End, and has since been repeatedly confirmed. The same observation was made, without knowing it had been previously noticed, by our friend Mr. Charles Konig."

This *Curculio* being of a resolute nature, attempted to eat his way out; "when discovered he was still alive, and had made a small hole through the side of the leaf, but was evidently becoming very weak. On opening the leaf, the fluid was found in considerable quantity around him, and was without doubt gradually overcoming him. The leaf being again allowed to close upon him, he soon died"*.

At the Meeting of this Association last year, Dr. Burdon Sanderson made a communication, which, from its remarkable character, was well worthy of the singular history of this plant; one by no means closed yet, but in which his observations will head a most interesting chapter. It is a generalization (now almost a household word) that all living things have a common bond of union in a substance (always present where life manifests itself) which underlies all their details of structure. This is called *protoplasm*. One of its most distinctive properties is its aptitude to contract; and when in any given organism the particles of protoplasm are so arranged that they act as it were in concert, they produce a cumulative effect which is very manifest in its results. Such a manifestation is found in the contraction of muscle; and such a manifestation we possibly have also in the contraction of the leaf of *Dionæa*.

The contraction of muscle is well known to be accompanied by certain electrical phenomena. When we place a fragment of muscle in connexion with a delicate galvanometer, we find that between the outside surface and a cut surface there is a definite current, due to what is called the electromotive force of the muscle. Now when the muscle is made to contract this electromotive force momentarily disappears. The needle of the galvanometer, deflected before, swings back towards the point of rest; there is what is called a *negative variation*. All students of the vegetable side of organized nature were astonished to hear from Dr. Sanderson that experiments which he had made proved to demonstration that when a leaf of *Dionæa* contracts, the effects produced are precisely similar to those which occur when muscle contracts†.

Not merely, then, are the phenomena of digestion in this wonderful plant like those of animals, but the phenomena of contractility agree with those of animals also.

Drosera.

Not confined to a single district in the New World, but distributed over the temperate parts of both hemispheres, in sandy and marshy places, are the curious plants called Sundews—the species of the genus *Drosera*. They are now known to be near congeners of *Dionæa*, a fact which was little more than guessed at when the curious habits which I am about to describe were first discovered.

Within a year of each other two persons (one an Englishman, the other a German) observed that the curious hairs which everyone notices on the leaf of *Drosera* were sensitive. This is the account which Mr. Gardom, a Derbyshire botanist, gives of what his friend Mr. Whateley, "an eminent London surgeon"‡, made out in 1780:—"On inspecting some of the contracted leaves we observed a small insect or fly very closely imprisoned therein, which occasioned some astonishment as to how it happened to get into so confined a situation. Afterwards, on Mr. Whateley's centrically pressing with a pin other leaves yet in their natural and expanded form, we observed a remarkable sudden and elastic spring of the leaves, so as to become inverted upwards and, as it were, encircling the pin, which evidently showed the method by which the fly came into its embarrassing situation"§. This must have been an account given from memory, and represents the movement of the hairs as much more rapid than it really is.

In July of the preceding year (though the account was not published till two years afterwards) Roth, in Germany, had remarked in *Drosera rotundifolia* and *longifolia* "that many leaves were folded together from the point towards the base, and that all the hairs were bent like a bow, but that there was no apparent change

* Notes on *Dionæa muscipula*, Ellis. Meehan's 'Gardeners' Monthly,' 1868, pp. 229–31.

† See Brit. Assoc. Report, 1873, Trans. Sect. p. 133; Proc. Royal Soc. vol. xxi. p. 495; Nature, June 11 & 18, 1874.

‡ Darwin, 'Botanic Garden,' pt. ii. p. 24.

§ Withering's 'Arrangement of British Plants,' 3rd ed. (1796) p. 325.

on the leaf-stalk." Upon opening these leaves, he says:—"I found in each a dead insect; hence I imagined that this plant, which has some resemblance to the *Dionæa muscipula*, might also have a similar moving power."

"With a pair of pliers I placed an ant upon the middle of the leaf of *D. rotundifolia*, but not so as to disturb the plant. The ant endeavoured to escape, but was held fast by the clammy juice at the points of the hairs, which was drawn out by its feet into fine threads. In some minutes the short hairs on the disk of the leaf began to bend, then the long hairs, and laid themselves upon the insect. After a while the leaf began to bend, and in some hours the end of the leaf was so bent inwards as to touch the base. The ant died in fifteen minutes, which was before all the hairs had bent themselves"*.

These facts, established nearly a century ago by the testimony of independent observers, have up to the present time been almost ignored; and Trécul †, writing in 1855, even thought that the facts were not true.

More recently, however, they have been repeatedly verified:—in Germany by Nitschke, in 1860 ‡; in America by a lady, Mrs. Treat, of New Jersey, in 1871 §; in this country by Mr. Darwin, and also by Mr. A. W. Bennett ‖.

To Mr. Darwin, who for some years past has had the subject under investigation, we are indebted, not merely for the complete confirmation of the facts attested by the earliest observers, but also for some additions to those facts, which are extremely important. The whole investigation still awaits publication at his hands; but some of the points which were established have been announced by Professor Asa Gray in America, to whom Mr. Darwin had communicated them §. He found that the hairs on the leaf of *Drosera* responded to a piece of muscle or other animal substance, while to any particle of inorganic matter they acted less efficiently, and the periods of subsequent reexpansion were widely different. To minute fragments of carbonate of ammonia they were more responsive.

The results of Mrs. Treat's experiments I will give in her own words:—

"Fifteen minutes past ten I placed bits of raw beef on some of the most vigorous leaves of *Drosera longifolia*. Ten minutes past twelve two of the leaves had folded around the beef, hiding it from sight. Half-past eleven on the same day, I placed living flies on the leaves of *D. longifolia*. At twelve o'clock and forty-eight minutes one of the leaves had folded entirely around its victim, and the other leaves had partially folded, and the flies had ceased to struggle. By half-past two four leaves had each folded around a fly. The leaf folds from the apex to the petiole, after the manner of its vernation. I tried mineral substances, bits of dry chalk, magnesia, and pebbles. In twenty-four hours neither the leaves nor the bristles had made any move in clasping these articles. I wet a piece of chalk in water, and in less than an hour the bristles were curving about it, but soon unfolded again, leaving the chalk free on the blade of the leaf."

Time will not allow me to enter into further details with respect to *Dionæa* and *Drosera*. The repeated testimony of various observers spread over a century, though at no time warmly received, must, I think, go a long way towards satisfying you that in this small family of the *Droseraceæ* we have plants which, in the first place, capture animals for purposes of food; and, in the second, digest and dissolve them by means of a fluid which is poured out for the purpose; and, thirdly, absorb the solution of animal matter which is so produced.

Before the investigations of Mr. Darwin had led other persons to work at the subject, the meaning of these phenomena was very little appreciated. Only a few years ago, Duchartre, a French physiological botanist, after mentioning the views of Ellis and Curtis with respect to *Dionæa*, expressed his opinion that the idea that its leaves absorbed dissolved animal substances was too evidently in disagreement with our knowledge of the function of leaves, and of the whole course of vegetable nutrition, to deserve being seriously discussed ¶.

* Quoted by Withering, *l. c.*

† "Je pense que ces organes ne sont pas excitables; je crois qu'ils ne sont pas susceptibles d'exécuter les mouvements qu'on leur attribue."—Ann. des Sc. Nat. 4e sér. t. iii. p. 303.

‡ Bot. Zeit. 1860, p. 229.

§ American Naturalist, 1873, p. 705.

‖ Brit. Assoc. Rep. 1873, Trans. Sect. p. 123.

¶ Éléments de Botanique, p. 358.

Perhaps if the *Droseraceæ* were an isolated case of a group of plants exhibiting propensities of this kind, there might be some reason for such a criticism. But I think I shall be able to show you that this is by no means the case. We have now reason to believe that there are many instances of these carnivorous habits in different parts of the vegetable kingdom, and among plants which have nothing else in common.

As another illustration I will take the very curious group of Pitcher-plants peculiar to the New World. And here also I think we shall find it most convenient to follow the historical order in the facts.

Sarracenia.

The genus *Sarracenia* consists of eight species, all similar in habit, and all natives of the eastern States of North America, where they are found more especially in bogs, and even in places covered with shallow water. Their leaves, which give them a character entirely their own, are pitcher-shaped or trumpet-like, and are collected in tufts springing immediately from the ground; and they send up at the flowering-season one or more slender stems bearing each a solitary flower. This has a singular aspect, due to a great extent to the umbrella-like expansion in which the style terminates; the shape of this, or perhaps of the whole flower, caused the first English settlers to give to the plant the name of Side-saddle flower*.

Sarracenia purpurea is the best known species. About ten years ago it enjoyed an evanescent notoriety, from the fact that its rootstock was proposed as a remedy for small-pox. It is found from Newfoundland southward to Florida, and is fairly hardy under open air cultivation in the British Isles. At the commencement of the seventeenth century, Clusius published a figure of it, from a sketch which found its way to Lisbon and thence to Paris†. Thirty years later Johnson copied this in his edition of Gerard's 'Herbal,' hoping "that some or other that travel into foreign parts may find this elegant plant, and know it by this small expression, and bring it home with them, so that we may come to a perfecter knowledge thereof"‡. A few years afterwards this wish was gratified. John Tradescant the younger found the plant in Virginia, and succeeded in bringing it home alive to England§. It was also sent to Paris from Quebec by Dr. Sarrazin, whose memory has been commemorated in the name of the genus by Tournefort‖.

The first fact which was observed about the pitchers was, that when they grew they contained water. But the next fact which was recorded about them was curiously mythical. Perhaps Morrison, who is responsible for it, had no favourable opportunities of studying them, for he declares them to be, what is by no means really the case, intolerant of cultivation ("respuere culturam videntur"). He speaks of the lid, which in all the species is tolerably rigidly fixed, as being furnished by providence with a hinge¶. This idea was adopted by Linnæus**, and somewhat amplified by succeeding writers, who declared that in dry weather the lid closed over the mouth, and checked the loss of water by evaporation. Catesby, in his fine work on the Natural History of Carolina, supposed that these water-receptacles might "serve as an asylum or secure retreat for numerous insects, from frogs and other animals which feed on them"††; and others followed Linnæus in regarding the pitchers as reservoirs for birds and other animals, more especially in times of drought—"præbet aquam sitientibus aviculis"‡‡.

The superficial teleology of the last century was easily satisfied, without looking far for explanations; but it is just worth while pausing for a moment to observe

* Miller, 'Figures of Plants described in the Gardeners' Dictionary,' ii. p. 161.

† Rariorum plantarum historia (1601), p. lxxxii.

‡ The 'Herbal,' enlarged by Th. Johnson (1633), p. 412.

§ Parkinson's 'Theatrum botanicum' (1640), p. 1235.

‖ Institutiones rei herbariæ (1719), p. 657.

¶ Plantarum Historia (1699), vol. iii. p. 533.

** Hortus Cliffortianus (1737), p. 497.

†† Vol. ii. p. 69 (1754).

‡‡ Prælectiones in ordines naturales plantarum (1792), p. 316; see also Miller, 'Figures, &c.,' p. 161.

that, although Linnæus had no materials for making any real investigation as to the purpose of the pitchers of Sarracenias, he very sagaciously anticipated the modern views as to their affinities. They are now regarded as very near allies of *Papaveraceæ*—precisely the position which Linnæus assigned to them in his fragmentary attempt at a true natural classification *. And, besides this, he also suggested the analogy which, improbable as it may seem at first sight, has been worked out in detail by Baillon between the leaves of *Sarracenia* and water-lilies. Linnæus seems to have supposed that *Sarracenia* was originally aquatic in its habits, that it had *Nymphæa*-like leaves, and that when it took to a terrestrial life its leaves became hollowed out, to contain the water in which they could no longer float †—in fact he showed himself to be an evolutionist of the true Darwinian type.

Catesby's suggestion was a very infelicitous one. The insects which visit these plants may find in them a retreat, but it is one from which they never return. Linnæus's correspondent Collinson remarked, in one of his letters, that "many poor insects lose their lives by being drowned in these cisterns of water" ‡; but William Bartram, the son of the botanist, seems to have been the first to have put on record, at the end of the last century, the fact that Sarracenias catch insects and put them to death in the wholesale way that they do §.

Before stopping to consider how this is actually achieved, I will carry the history a little further.

In the two species in which the mouth is unprotected by the lid it could not be doubted that a part, at any rate, of the contained fluid was supplied by rain; but in *Sarracenia variolaris*, in which the lid closes over the mouth, so that rain cannot readily enter it, there is no doubt that a fluid is secreted at the bottom of the pitchers, which probably has a digestive function. William Bartram, in the preface to his 'Travels,' described this fluid; but he was mistaken in supposing that it acted as a lure. There is a sugary secretion which attracts insects, but this is only found at the upper part of the tube. Bartram, however, must be credited with the suggestion, which he, however, only put forward doubtfully, that the insects were dissolved in the fluid, and then became available for the alimentation of the plants.

Sir J. E. Smith, who published a figure and description of *Sarracenia variolaris*, noticed that it secreted fluid, but was content to suppose that it was merely the gaseous products of the decomposition of insects that subserved the processes of vegetation ‖. In 1829, however, thirty years after Bartram's book, Burnett wrote a paper containing a good many original ideas expressed in a somewhat quaint fashion, in which he very strongly insisted on the existence of a true digestive process in the case of *Sarracenia*, analogous to that which takes place in the stomach of an animal ¶.

Our knowledge of the habits of *Sarracenia variolaris* is now pretty complete, owing to the observations of two South Carolina physicians. One of them, Dr. Macbride, made his observations half a century ago, but they had, till quite recently, completely fallen into oblivion. He devoted himself to the task of ascertaining why it was that *Sarracenia variolaris* was visited by flies, and how it was that it captured them. This is what he ascertained:—

"The cause which attracts flies is evidently a viscid substance, resembling honey, secreted by or exuding from the internal surface of the tube. From the margin, where it commences, it does not extend lower than one fourth of an inch. The falling of the insect as soon as it enters the tube is wholly attributable to the downward or inverted position of the hairs of the internal surface of the leaf. At the bottom of the tube split open, the hairs are plainly discernible, pointing downwards; as the eye ranges upward they gradually become shorter and attenuated, till at or just below the surface covered by the bait they are no longer perceptible to the naked eye, nor to the most delicate touch. It is here that the fly cannot take a hold sufficiently strong to support itself, but falls" **.

* Classes Plantarum (1738), p. 500. † Systema naturæ, ed. xiii. vol. ii. p. 361 (1767).
‡ Smith's 'Correspondence of Linnæus,' vol. i. p. 69 (1765).
§ Travels through North and South Carolina, Georgia, Florida (1791).
‖ Introduction to Physiological and Systematical Botany (1807), p. 196.
¶ Quarterly Journal of Science and Art, vol. ii. p. 290 (1829).
** Trans. Linn. Soc. vol. xii. pp. 48–52 (1815).

Dr. Mellichamp, who is now resident in the district in which Dr. Macbride made his observations, has added a good many particulars to our knowledge. He first investigated the fluid which is secreted at the bottom of the tubes. He satisfied himself that it was really secreted, and describes it as mucilaginous, but leaving in the mouth a peculiar astringency. He compared the action of this fluid with that of distilled water on pieces of fresh venison, and found that after fifteen hours the fluid had produced most change, and also most smell; he therefore concluded that as the leaves when stuffed with insects become most disgusting in odour, we have to do, not with a true digestion, but with an accelerated decomposition. Although he did not attribute any true digestive power to the fluid secreted by the pitchers, he found that it had a remarkable anæsthetic effect upon flies immersed in it. He remarked that "a fly when thrown into water is very apt to escape, as the fluid seems to *run* from its wings," but it never escaped from the *Sarracenia*-secretion. About half a minute after being thrown in, the fly became to all appearance dead, though if removed it gradually recovered in from half an hour to an hour. According to Dr. Mellichamp, the sugary lure discovered by Dr. Macbride at the mouth of the pitchers is not found on either the young ones of one season, nor the older ones of the previous year. He found, however, that about May it could be detected without difficulty; and, more wonderful still, that there is a honey-baited pathway leading directly from the ground to the mouth, along the broad wing of the pitcher, up which insects are led to their destruction *.

From these narratives it is evident that there are two very different types of pitcher in *Sarracenia*, and an examination of the species shows that there must probably be three. These may be primarily classified into those with the mouth open and lid erect, and which consequently receive the rain-water in more or less abundance; and those with the mouth closed by the lid, into which rain can hardly, if at all, find ingress.

To the first of these belongs the well-known *S. purpurea*, with inclined pitchers and a lid so disposed as to direct all the rain that falls upon it into the pitcher; also *S. flava*, *rubra*, and *Drummondii*, all with erect pitchers and vertical lids. In these three the lid in a young state arches over the mouth, and in an old state stands nearly erect, and has the sides so reflected that the rain which falls on its upper surface is guided down the outside of the back of the pitcher, as if to prevent the flooding of the latter.

To the second group belong *S. psittacina* and *S. variolaris*.

The tissues of the internal surfaces of the pitchers are singularly beautiful. They have been described in one species only, *S. purpurea*, by August Vogl †; but from this all the other species which I have examined differ materially. Beginning from the upper part of the pitcher, there are four surfaces, characterized by different tissues, which I shall name and define as follows:—

1. An *attractive* surface, occupying the inner surface of the lid, which possesses stomata, and (in common with the mouth of the pitcher) with minute honey-secreting glands; it is further often more highly coloured than any other part of the pitcher, in order to attract insects to the honey.

2. A *conducting* surface, which is opaque, formed of glassy cells, which are produced into deflexed, short, conical processes. These processes, overlapping like the tiles of a house, form a surface down which an insect slips, and affords no foothold to an insect attempting to crawl up again.

3. A *glandular* surface (seen in *S. purpurea*), which occupies a considerable portion of the cavity of the pitcher below the conducting surface. It is formed of a layer of epidermis with sinuous cells, and is studded with glands; and being smooth and polished, this too affords no foothold for escaping insects.

4. A *detentive* surface, which occupies the lower part of the pitcher, in some cases for nearly its whole length. It possesses no cuticle, and is studded with deflexed, rigid, glass-like, needle-formed hairs, which further converge towards the axis of

* Dr. Mellichamp's observations were communicated to Prof. Asa Gray, who gave an account of them in the 'New York Tribune,' which was reprinted in the 'Gardeners' Chronicle,' June 27, 1874, p. 818.

† Wien. Sitzungsberichte der k. k. Akad. (1865) vol. l. p. 281.

the diminishing cavity; so that an insect, if once amongst them, is effectually detained, and its struggles have no other result than to wedge it lower and more firmly in the pitcher.

Now it is a very curious thing that in *S. purpurea*, which has an open pitcher so formed as to receive and retain a maximum of rain, no honey-secretion has hitherto been found, nor has any water been seen to be secreted in the pitcher; it is further the only species in which (as stated above) I have found a special glandular surface, and in which no glands occur on the detentive surface. This concurrence of circumstances suggests the possibility of this plant either having no proper secretion of its own, or only giving it out after the pitcher has been filled with rain-water.

In *S. flava*, which has open-mouthed pitchers and no special glandular surface, I find glands in the upper portion of the detentive surface, amongst the hairs, but not in the middle or lower part of the same surface. It is known that *S. flava* secretes fluid, but under what precise conditions I am not aware. I have found none but what may have been accidentally introduced in the few cultivated specimens which I have examined, either in the full-grown state or in the half-grown, when the lid arches over the pitcher. I find the honey in these as described by the American observers, and honey-secreting glands on the edge of the wing of the pitcher, together with similar glands on the outer surface of the pitcher, as seen by Vogl in *S. purpurea*.

Of the pitchers with closed mouths, I have examined those of *S. variolaris* only, whose tissues closely resemble those of *S. flava*. That it secretes a fluid noxious to insects there is no doubt, though in the specimens I examined I found none.

There is obviously thus much still to be learned with regard to *Sarracenia*, and I hope that American botanists will apply themselves to this task. It is not probable that three pitchers so differently constructed as those of *S. flava*, *purpurea*, and *variolaris*, and presenting such differences in their tissues, should act similarly. The fact that insects normally become decomposed in the fluid of all, would suggest the probability that they all feed on the products of decomposition; but as yet we are absolutely ignorant whether the glands within the pitchers are secretive or absorptive, or both—if secretive, whether they secrete water or a solvent; and if absorptive, whether they absorb animal matter or the products of decomposition.

It is quite likely that just as the saccharine exudation only makes its appearance during one particular period in the life of the pitcher, so the digestive functions may also be only of short duration. We should be prepared for this from the case of the *Dionæa*, the leaves of which cease after a time to be fit for absorption, and become less sensitive. It is quite certain that the insects which go on accumulating in the pitchers of Sarracenias must be far in excess of its needs for any legitimate process of digestion. They become decomposed; and various insects, too wary to be entrapped themselves, seem habitually to drop their eggs into the open mouths of the pitchers, to take advantage of the accumulation of food *. The old pitchers are consequently found to contain living larvæ and maggots, a sufficient proof that the original properties of the fluid which they secreted must have become exhausted †; and Barton tells us that various insectivorous birds slit open the pitchers with their beaks to get at the contents ‡. This was probably the origin of Linnæus's statement, that the pitchers supplied birds with water.

The pitchers finally decay, and part, at any rate, of their contents must supply some nutriment to the plant by fertilizing the ground in which it grows.

Darlingtonia.

I cannot take leave of *Sarracenia* without a short notice of its near ally, *Darlingtonia*, a still more wonderful plant, an outlier of *Sarracenia* in geographical distribution, being found at an elevation of 5000 feet on the Sierra Nevada of California, far west of any locality inhabited by *Sarracenia*. It has pitchers of two forms; one, peculiar to the infant state of the plant, consists of narrow, somewhat twisted,

* Barton, Tilloch's 'Phil. Mag.' (1812), vol. xxxix. p. 107; Smith, 'Introd. to Botany,' p. 196; Macbride, *l. c.* p. 51.

† See Mellichamp's observations, already quoted.

‡ *L. c.* p. 115.

trumpet-shaped tubes, with very oblique open mouths, the dorsal lip of which is drawn out into a long, slender, arching, scarlet hood, that hardly closes the mouth. The slight twist in the tube causes these mouths to point in various directions, and they entrap very small insects only. Before arriving at a state of maturity the plant bears much larger, suberect pitchers, also twisted, with the lip produced into a large inflated hood, that completely arches over a very small entrance to the cavity of the pitcher. A singular orange-red, flabby, two-lobed organ hangs from the end of the hood, right in front of the entrance, which, as I was informed last week by letter from Professor Asa Gray, is smeared with honey on its inner surface. These pitchers are crammed with large insects, especially moths, which decompose in them, and result in a putrid mass. I have no information of water being found in its pitchers in its native country, but have myself found a slight acid secretion in the young states of both forms of pitcher.

The tissues of the inner surfaces of the pitchers of both the young and old plant I find to be very similar to those of *Sarracenia variolaris* and *S. flava*.

Looking at a flowering specimen of *Darlingtonia*, I was struck with a remarkable analogy between the arrangement and colouring of the parts of the leaf and of the flower. The petals are as highly coloured as the flap of the pitcher, and between each pair of petals is a hole (formed by a notch in the opposed margins of each) leading to the stamens and stigma. Turning to the pitcher, the relation of its flap to its entrance is somewhat similar. Now we know that coloured petals are specially attractive organs, and that the object of their colour is to bring insects to feed on the pollen or nectar, and in this case, by means of the hole, to fertilize the flower; and that the object of the flap and its sugar is also to attract insects, but with a very different result, cannot be doubted. It is hence conceivable that this marvellous plant lures insects to its flowers for one object, and feeds them while it uses them to fertilize itself, and that, this accomplished, some of its benefactors are thereafter lured to its pitchers for the sake of feeding itself!

But to return from mere conjecture to scientific earnest, I cannot dismiss *Darlingtonia* without pointing out to you what appears to me a most curious point in its history; which is, that the change from the slender, tubular, open-mouthed, to the inflated closed-mouthed pitchers is, in all the specimens which I have examined, absolutely sudden in the individual plant. I find no pitchers in an intermediate stage of development. This, a matter of no little significance in itself, derives additional interest from the fact that the young pitchers to a certain degree represent those of the Sarracenias with open mouths and erect lids, and the old pitchers those of the Sarracenias with closed mouths and globose lids. The combination of representative characters in an outlying species of a small order cannot but be regarded as a marvellously significant fact in the view of those morphologists who hold the doctrine of evolution.

Nepenthes.

The genus *Nepenthes* consists of upwards of 30 species of climbing half shrubby plants, natives of the hotter parts of the Asiatic Archipelago from Borneo to Ceylon, with a few outlying species in New Caledonia, in Tropical Australia, and in the Seychelle Islands on the African coast. Its pitchers are abundantly produced, especially during the younger state of the plants. They present very considerable modifications of form and external structure, and vary greatly in size, from little more than an inch to almost a foot in length; one species, indeed, which I have here from the mountains of Borneo, has pitchers which, including the lid, measure a foot and a half, and its capacious bowl is large enough to drown a small quadruped or bird.

The structure of the pitcher of *Nepenthes* is less complicated on the whole than that of *Sarracenia*, though some of its tissues are much more highly specialized. The pitcher itself is here not a transformed leaf, as in *Sarracenia*, nor is it a transformed leaf-blade, like that of *Dionæa*, but an appendage of the leaf developed at its tip, and answers to a water-secreting gland that may be seen terminating the mid-rib of the leaf of certain plants. It is furnished with a stalk, often a very long one, which, in the case of pitchers formed on leaves high up the stem, has (before the full development of the pitcher) the power of twisting like a tendril round

neighbouring objects, and thus aiding the plant in climbing, sometimes to a great height, in the forest.

In most species the pitchers are of two forms, one appertaining to the young, the other to the old state of the plant, the transition from one form to the other being gradual. Those of the young state are shorter and more inflated; they have broad fringed longitudinal wings on the outside, which are probably guides to lead insects to the mouth; the lid is smaller and more open, and the whole interior surface is covered with secreting-glands. Being formed near the root of the plant, these pitchers often rest on the ground; and in species which do not form leaves near the root, they are sometimes suspended from stalks which may be fully a yard long, and which bring them to the ground. In the older state of the plant the pitchers are usually much longer, narrower, and less inflated, trumpet-shaped, or even conical; the wings also are narrower, less fringed, or almost absent. The lid is larger and slants over the mouth, and only the lower part of the pitcher is covered with secreting-glands, the upper part presenting a tissue analogous to the conducting-tissue of *Sarracenia*, but very different anatomically. The difference in structure of these two forms of pitcher, if considered in reference to their different positions on the plant, forces the conclusion on the mind, that the one form is intended for ground game, the other for winged game. In all cases the mouth of the pitcher is furnished with a thickened corrugated rim, which serves three purposes—it strengthens the mouth and keeps it distended, it secretes honey (at least in all the species I have examined under cultivation, for I do not find that any other observer has noticed the secretion of honey by *Nepenthes*), and it is in various species developed into a funnel-shaped tube that descends into the pitcher and prevents the escape of insects, or into a row of incurved hooks that are in some cases strong enough to retain a small bird, should it, when in search of water or insects, thrust its body beyond a certain length into the pitcher.

In the interior of the pitcher of *Nepenthes* there are three principal surfaces—an *attractive, conductive,* and a *secretive* surface; the *detentive* surface of *Sarracenia* being represented by the fluid secretion, which is here invariably present at all stages of growth of the pitcher.

The attractive surfaces of *Nepenthes* are two, those, namely, of the rim of the pitcher and of the under surface of the lid, which is provided in almost every species with honey-secreting glands, often in great abundance. These glands consist of masses of cells, each imbedded in a cavity of the tissue of the lid and encircled by a guard-ring of glass-like cellular tissue. As in *Sarracenia*, the lid and mouth of the pitcher are more highly coloured than any other part, with the view of attracting insects to their honey. It is a singular fact that the only species known to me that wants these honey-glands on the lid is the *N. ampullaria*, whose lid, unlike that of the other species, is thrown back horizontally. The secretion of honey on a lid so placed would tend to lure insects away from the pitcher instead of into it.

From the mouth to a variable distance down the pitcher is an opaque glaucous surface, resembling in colour and appearance the glandular surface of *Sarracenia*, and like it affording no foothold to insects, but otherwise wholly different; it is formed of a fine network of cells, covered with a glass-like cuticle, and studded with minute reniform transverse excrescences.

The rest of the pitcher is entirely occupied with the secretive surface, which consists of a cellular floor crowded with circular glands in inconceivable numbers. Each gland precisely resembles a honey-gland of the lid, and is contained in a pocket of the same nature, but semicircular, with the mouth downwards, so that the secreted fluid all falls to the bottom of the pitcher. In *Nepenthes Rafflesiana* three thousand such glands occur on a square inch of the inner surface of the pitcher. I have ascertained that, as was indeed to be expected, they secrete the fluid which is contained in the bottom of the pitcher before this opens, and that the fluid is always acid.

The fluid, though invariably present, occupies a comparatively small portion of the secretive surface of the pitcher. When the fluid is emptied out of a fully formed pitcher that has not received animal matter, it collects again, but in comparatively very small quantities; and the formation goes on for many days, and to some

extent, even after the pitcher has been removed from the plant. I do not find that placing inorganic substances in the fluid causes an increased secretion, but I have twice observed a considerable increase of fluid in pitchers after putting animal matter in the fluid.

To test the digestive powers of *Nepenthes* I have closely followed Mr. Darwin's treatment of *Dionæa* and *Drosera*, employing cubes of boiled white of egg, raw meat, fibrine, and cartilage. In all cases the action is most evident, in some surprising. After twenty-four hours' immersion the edges of the cubes of white of egg are eaten away and the surfaces gelatinized. Fragments of meat are rapidly reduced; and pieces of fibrine weighing several grains dissolve and totally disappear in two or three days. With cartilage the action is most remarkable of all; lumps of this weighing eight and ten grains are half gelatinized in twenty-four hours, and in three days the whole mass is greatly diminished, and reduced to a clear transparent jelly. After drying some cartilage in the open air for a week, and placing it in an unopened but fully formed pitcher of *N. Rafflesiana*, it was acted upon similarly and very little more slowly.

That this process, which is comparable to digestion, is not wholly due to the fluid first secreted by the glands, appears to me most probable; for I find that very little action takes place in any of the substances placed in the fluid drawn from pitchers and put in glass tubes; nor has any followed after six days' immersion of cartilage or fibrine in pitchers of *N. ampullaria* placed in a cold room, whilst on transferring the cartilage from the pitcher of *N. ampullaria* in the cold room to one of *N. Rafflesiana* in the stove it was immediately acted upon. Comparing the behaviour of fibrine, meat, and cartilage placed in tubes of *Nepenthes*-fluid, with that in tubes of distilled water, I observed that their disintegration is three times more rapid in the fluid; but this disintegration is wholly different from that which follows the immersion of these substances in the fluid of the pitcher of a living plant.

In the case of small portions of meat, $\frac{1}{2}$–2 grains, all seems to be absorbed; but with 8–10 grains of cartilage it is not so—a certain portion disappears, the rest remains as a transparent jelly, and finally becomes putrid, but not till after many days. Insects appear to be acted upon somewhat differently; for after several days' immersion of a large piece of cartilage I found that a good-sized cockroach, which had followed the cartilage and was drowned for his temerity, in two days became putrid. After removing the cockroach the cartilage remained inodorous for many days. In this case no doubt the antiseptic fluid had permeated the tissue of the cartilage, whilst enough did not remain to penetrate the chitinous hard covering of the insect, which consequently decomposed.

In the case of cartilage placed in fluid taken from the pitcher, it becomes putrid, but not so soon as if placed in distilled water.

From the above observations it would appear probable that a substance acting as pepsine does is given off from the inner wall of the pitcher, but chiefly after placing animal matter in the acid fluid; but whether this active agent flows from the glands, or from the cellular tissue in which they are imbedded, I have no evidence to show.

I have here not alluded to the action of these animal matters in the cells of the glands, which, as has been observed by Mr. Darwin in *Drosera*, produces remarkable changes in their protoplasm, ending in their discoloration. Not only is there aggregation of the protoplasm in the gland-cells, but the walls of the cells themselves become discoloured, and the glandular surface of the pitcher that at first was of a uniform green, becomes covered with innumerable brown specks (which are the discoloured glands). After the function of the glands is exhausted, the fluid evaporates and the pitcher slowly withers.

At this stage I am obliged to leave this interesting investigation. That *Nepenthes* possesses a true digestive process, such as has been proved in the case of *Drosera*, *Dionæa*, and *Pinguicula*, cannot be doubted. This process, however, takes place in a fluid which deprives us of the power of following it further by direct observation. We cannot here witness the pouring out of the digestive principle; we must assume its presence and nature from the behaviour of the animal matter placed in the fluid in the pitcher. From certain characters of the cellular tissue of the interior walls of the pitcher, I am disposed to think that it takes little part in the processes of

either digestion or assimilation, and that these, as well as the pouring out of the acid fluid, are all functions of the glands.

In what I have said, I have described the most striking instances of plants which seem to invert the order of nature, and to draw their nutriment (in part at least) from the animal kingdom, which it is often held to be the function of the vegetable kingdom to sustain.

I might have added some additional cases to those I have already dwelt upon. Probably, too, there are others still unknown to science, or whose habits have not yet been detected. Delpino, for example, has suggested that a plant first described by myself from Tierra del Fuego—*Caltha dionææfolia* *—is so analogous in the structure of its leaves to *Dionæa*, that it is difficult to resist the conviction that its structure also is adapted for the capture of small insects †.

But the problem that forces itself upon our attention is, how does it come to pass that these singular aberrations from the otherwise uniform order of vegetable nutrition make their appearance in remote parts of the vegetable kingdom? why are they not more frequent? and how were such extraordinary habits brought about or contracted? At first sight the perplexity is not diminished by considering (as we may do for a moment) the nature of ordinary vegetable nutrition. Vegetation, as we see it everywhere, is distinguished by its green colour, which we know depends on a peculiar substance called chlorophyl—a substance which has the singular property of attracting to itself the carbonic acid gas which is present in minute quantities in the atmosphere, of partly decomposing it so far as to set free a portion of its oxygen, and of recombining it with the elements of water, to form those substances, such as starch, cellulose, and sugar, out of which the framework of the plant is constructed. But, besides these processes, the roots take up certain matters from the soil. Nitrogen forms nearly four fifths of the air we breathe, yet plants can possess themselves of none of it in the free uncombined state. They withdraw nitrates and salts of ammonia in minute quantities from the ground, and from these they build up with starch, or some analogous material, albuminoids or protein compounds, necessary for the sustentation and growth of protoplasm.

At first sight nothing can be more unlike this than a *Dionæa* or a *Nepenthes* capturing insects, pouring out a digestive fluid upon them, and absorbing the albuminoids of the animal, in a form probably directly capable of appropriation for its own nutrition. Yet there is something not altogether wanting in analogy in the case of the most regularly constituted plants. The seed of the castor-oil plant, for example, contains, besides the embryo seedling, a mass of cellular tissue or endosperm filled with highly nutritive substances. The seedling lies between masses of this and is in contact with it; and as the warmth and moisture of germination set up changes which bring about the liquefaction of the contents of the endosperm, and the embryo absorbs them, it grows in so doing, and at last, having taken up all it can from the exhausted endosperm, develops chlorophyl in its cotyledons under the influence of light, and relies on its own resources.

A large number of plants, then, in their young condition borrow their nutritive compounds ready prepared; and this is, in effect, what carnivorous plants do, more or less, later in life. That this is not merely a fanciful way of regarding the relation of the embryo to the endosperm, is proved by the ingenious experiments of Van Tieghem, who has succeeded in substituting for the real, an artificial endosperm, consisting of appropriate nutritive matters ‡. Except that the embryo has its food given to it in a manner which needs no digestion (a proper concession to its infantine state), the analogy here with the mature plants which feed on organic food seems to be complete.

But we are beginning also to recognize the fact that there are a large number of flowering plants that pass through their lives without ever doing a stroke of the work that green plants do. These have been called saprophytes. *Monotropa*, the curious bird's-nest orchis (*Neottia Nidus-avis*), *Epipogium*, and *Corallorhiza* are instances of British plants which nourish themselves by absorbing the partially

* Flora antarctica, vol. ii. p. 229, t. 84.

† Ulteriori osservazioni sulla Dicogamia, parte prima, p. 16.

‡ Ann. des Sc. Nat. 5e sér. vol. xvii. pp. 205–224 (1873).

decomposed materials of other plants in the shady or marshy places which they inhabit. They reconstitute these products of organic decomposition, and build them up once more into an organism. It is curious to notice, however, that the tissues of *Neottia* still contain chlorophyl in a nascent though useless state, and that if a plant of it be immersed in boiling water the characteristic green colour reveals itself *. *Epipogium* and *Corallorhiza* have lost their proper absorbent organs; they are destitute of roots, and take in their food by the surfaces of their underground stem-structures †.

The absolute difference between plants which absorb and nourish themselves by the products of the decomposition of plant-structures, and those which make a similar use of animal structures, is not very great. We may imagine that plants accidentally permitted the accumulation of insects in some parts of their structure, and the practice became developed because it was found to be useful. It was long ago suggested that the receptacle formed by the connate leaves of *Dipsacus* might be an incipient organ of this kind ‡; and though no insectivorous habit has ever been brought home to that plant, the suggestion is not improbable.

Linnæus and, more lately, Baillon § have shown how a pitcher of *Sarracenia* may be regarded as a modification of a leaf of the *Nymphæa* type. We may imagine such a leaf first becoming hollow, and allowing *débris* of different kinds to accumulate; these would decompose, and a solution would be produced, some of the constituents of which would diffuse themselves into the subjacent plant-tissues. This is in point of fact absorption; and we may suppose that in the first instance (as perhaps still in *Sarracenia purpurea*) the matter absorbed was merely the saline nutritive products of decomposition, such as ammoniacal salts. The act of digestion (that process by which soluble food is reduced without decomposition to a soluble form fitted for absorption) was doubtless subsequently acquired.

The secretion, however, of fluids by plants is not an unusual phenomenon. In many Aroids a small gland at the apex of the leaves secretes fluid, often in considerable quantities ‖; and the pitcher of *Nepenthes* is, as I have shown elsewhere ¶, only a gland of this kind enormously developed. May not, therefore, the wonderful pitchers and carnivorous habit of *Nepenthes* have both originated by natural selection out of some such honey-secreting gland as we still find developed near that part of the pitcher which represents the tip of the leaf? We may suppose insects to have been entangled in the viscid secretion of such a gland, and to have perished there. Delpino has recorded the fact that the spathe of *Alocasia odora* secretes an acid fluid which destroys the slugs that visit it, and which he believes subserves its fertilization **. Here any process of nutrition can only be secondary. But the fluids of plants are in the great majority of cases acid, and when exuded would be almost certain to bring about some solution in substances with which they came in contact. Thus the acid secretions of roots were found by Sachs †† to corrode polished marble surfaces with which they came in contact, and thus to favour the absorption of mineral matter. The subsequent differentiation of the secreting organs of the pitcher into aqueous, saccharine, and acid would follow, *pari passu*, with the evolution of the pitcher itself, according to those mysterious laws which result in the correlation of organs and functions throughout the kingdom of Nature, and which, in my apprehension, transcend in wonder and interest those of the origin of species.

The solution of albuminoid substances requires, however, besides a suitable acid, the presence of some other albuminoid substance analogous to pepsine. Such substances, however, are frequent in plants. Besides the well-known diastase, which converts the starch of malt into sugar, there are other instances—in the synaptase

* Prillieux, Ann. des Sc. Nat. 5e sér. vol. xix. p. 108.

† Sachs's 'Lehrbuch der Bot.' 3rd ed. p. 629.

‡ Burnett, *l. c.* p. 287; Darwin, 'Bot. Gard.' pt. i. p. 37; Kirby and Spence's 'Entomology,' 7th ed. p. 167.

§ Adansonia, vol. ix. pp. 331 & 380.

‖ See Ann. & Mag. Nat. Hist. 1848, vol. i. p. 188, where a species of *Caladium* is said to have secreted half a pint of fluid from each leaf in the course of the night.

¶ Trans. Linn. Soc. vol. xxii. pp. 415–424. Substantially the same view of their origin appears to have been taken by Griffith, Posth. Papers, vol. ii. p. 77.

** *Loc. cit.* p. 237.

†† Lehrbuch der Botanik, 3rd ed. p. 611.

which determines the formation of hydrocyanic acid from emulsine, and the myrosin which similarly induces the formation of oil of mustard. We need not wonder, then, if the fluid secreted by a plant should prove to possess the ingredients necessary for the digestion of insoluble animal matters.

These remarks will, I hope, lead you to see that though the processes of plant-nutrition are in general extremely different from those of animal-nutrition, and involve very simple compounds, yet that the protoplasm of plants is not absolutely prohibited from availing itself of food such as that by which the protoplasm of animals is nourished; under which point of view these phenomena of carnivorous plants will find their place as one more link in the continuity of nature.

Anthropology.

Address to the Department of Anthropology. By Sir William R. Wilde, *M.D., M.R.I.A., Chevalier of the Order of the Polar Star of Sweden.*

I have to thank the Association for having honoured me with the Directorship of the Anthropological Department of the Biological Section. It will be in the recollection of some of those I have the honour of addressing, that when this Association last met in Dublin, in 1857, I had the pleasing duty of conducting a large section of some of its most distinguished members to the Western Islands of Aran off the coast of Galway—the last fortified resting-place of one of the earliest races that occupied this island, and who, with their faces turned to the far West, may have had some dim notion in their minds (even at the time of their expulsion from the mainland) of that exodus which was carried out by other means than man's unaided hand in our own time.

I cannot refrain here from alluding to a personal as well as public loss which I and the British Association have sustained in the death of one of its most ardent original promoters and one of its most hard-working officers. Learned in a vast variety of pursuits—unflagging in whatever he took in hand—exact in his knowledge—energetic in his investigations — not discursive, but rather chary in his friendships, yet always courteous and willing to lend a helping hand to the beginner (as I and others know)—lived and died Professor Phillips, of Oxford.

Anthropology:—"the science of man," so called; his origin, age, and distribution on our globe; his physical conformation and susceptibility of cultivation; his various forms of speech; his laws, habits, manners, customs, weapons, and tools; his archaic markings, as also his pictorial remains; his tombs; his ideographic and phonetic or alphabetic writing, down to his present culture in different countries; and his manufactures, arts, and degrees of intelligence in his different phases of life throughout the world,—are all presented for investigation by this Section of the Association.

How am I to treat this vast subject during the short space allowed for the delivery of an address? Suppose I were to confine myself to what has been done during the past year, I might, by carefully culled accounts, present you with the physical characters, customs, and arts of the Ashantees with whom we have so lately come in contact; or, again, I might refer to those discoveries on the Troad that so vividly bring before us some of the arts and sciences described by Homer, and particularly those ornaments and utensils that show cultivation of a peculiar kind in pottery and metal work, especially of gold, belonging to a very remote era. I say *peculiar*, because I think we are too much in the habit of attributing high cultivation in social life, morals, and domestic virtues to those peoples whose remains present specimens of great metallurgic skill or a taste for the ceramic art.

Concerning the investigations so admirably conducted by Dr. Schliemann, we must all regret that Sir John Lubbock's proposition to the Government—to expend a few paltry thousands in allowing England to put its sickle into the harvest and reap some of the golden grain illustrative of the time of Homer and his contem-

poraries, which others may carry off to enrich the art treasures of countries not perhaps so wealthy in their exchequer as the British Empire—was not acceded to.

I cannot in passing refrain from alluding to two of these archæological researches so graphically brought forward by Mr. Gladstone in his critical review of 'Homer's Place in History,' which appeared in last June's 'Contemporary Review.' In one of these notices he alludes to the fact of a number of implements and utensils, found by General Cesnola in Cyprus, "exhibiting so extensive a use of uncombined copper, and so clear and wide an application of that metal to cutting purposes, as at once to suggest a modification of the theories of those who, in arranging what may be termed their metallic periods, assume that the age of bronze invariably came in immediate succession to the age of stone." And, again, referring to the great *Find* on the Troad, he writes, "The excavations, according to our present information, present to us copper as the staple material of the implements, utensils, and of the weapons (so far as they were metallic) of the inhabitants of Troy;—so do the poems." No better authority could be adduced on the latter subject; but if the learned writer had inspected our great collection of antique metal work in the National Museum of the Royal Irish Academy before it was disarranged, and had he done the author of the 'Descriptive Catalogue' of these antiquities (written eighteen years ago) the honour of reading the dissertation on our early metallic work, he would have seen that copper weapons, tools, and implements were the "forerunners of the mixed metal—bronze or brass" in Ireland.

I am not going into the subject of the single or multiple origin of man; nor do I intend discussing the question of the cave-man, or the race whose early implements, weapons, and tools are found in the drift.

Upon the subject of what is termed "*Prehistoric*" I may possess peculiar opinions. What is prehistoric? Does it mean pre-Adamite? or does it refer only to the times when some scribe wrote down, from word of mouth, the bardic tale, the genealogy or annal, no matter of what era? We do *not* know where nor by whom these annals were first committed to writing, nor what means were taken to alter them; but we possess what cannot be falsified by the scribe; and although styled prehistoric, they are far more truthfully historic than the writing that no doubt was largely interfered with, and which, if old, now requires a gloss to interpret it. The grassy mound or circle, the stones erected into a cromleach, the great sepulchral mound, the cinerary urn, the stone weapon or tool, the grain-rubber for triturating cereal food, the harpoon for spearing fish, the copper and bronze tools and weapons, and the gold ornaments of the most early tribes,—all now are, in their way, far more truthful than any thing that could have been committed to writing, even if there were letters in that day. They are litanies in stone, dogmata in metal, and sermons preaching from the grassy mound.

But how are we to use or apply these early scriptures of history so as to advance Anthropology and to educate the public mind? That is a serious question, well worthy the attention of this Association. One means, at least, is by properly arranged museums, to which, I am happy to say, the working man may now resort for recreation and instruction upon almost every day of the week, when his business permits. I must here say a word upon the subject of museums. If you would not have museums like what we remember them to have been—incongruous collections of all manner of articles, including cracked china, painted or engraved oyster-shells, heads of New-Zealanders tattooed, ostrich-eggs, and, as Romeo found in the shop of the apothecary, "an alligator stuffed and other skins of ill-shaped fishes,"—you must make some sort of archæological arrangement; and it ought to be upon some definite scheme or plan, not fanciful or incongruous, but historic, technical, or art-teaching. The educated man can pick out for himself articles that give him instruction, or that support or militate against his own special theory; but he has come to the inquiry with a skilled eye. The public mind should be educated by skilled artists, not merely amused by amateur decorators *.

* The compartment now used as a "reading-room" at the Royal Irish Academy was specially constructed by Government for a Museum from its foundation to its roof, and was, as all such structures should be, well lighted from the top. It was I who proposed the *extension* of the Museum into another room, and the influence of Lord Talbot de Malahide largely assisted to procure the funds for that object.

I endeavoured, in arranging the antique articles in our Royal Irish Academy, to exhibit *progress* from the simplest and rudest to the most complicate and ornate, taking Material and Use as my basis. We have thus presented to us a wide field of culture and investigation. Looking back upon my work I do not regret that arrangement, the more particularly as in but very few instances indeed can we identify the special bronze celt, arrow-head, spear, sword, javelin, or battle-axe with the names recorded in the MSS. referring to pre-Christian times. We must be cautious in accepting the absolute words of documents transmitted from these times, such as those giving descriptions of a memorable fight between two heroes, which state that one of them wore among his defensive armour a mill-stone enveloped in a silken fabric upon his stomach!

Now I do not desire to press any special theory of museum arrangement upon this Meeting, but I do wish to impress upon it the necessity for having some plan adopted for educational purposes in Antiquarian Collections. I do not care what that arrangement is, provided it is upon a definite plan; but except for some special purpose, or in accordance with the request of the donor, I certainly object to having placed in immediate contiguity early bronze shields, antique celts and swords, together with crosiers and crucifixes illustrative of the Christian period.

I care not whether a museum is to be arranged according to the system of my old friend and instructor Thomsen, of Copenhagen, as by the stone, bronze, iron, and other "Ages," provided such can be faithfully carried out—or whether my own system of *Material* and *Use* may be adopted; but this I do assert, that in this present age of enlightenment some system should be pursued by which the public would be both interested and instructed. I do not think that any Government should support a museum that was not properly arranged.

Instead of entering into the wide domain of Anthropology generally, I shall follow the example of my predecessor, Dr. Beddoe, regarding Yorkshire, and confine my remarks to the subject of the early races who peopled Ireland in consecutive order, their remains still existing, and an inquiry as to what vestiges of those different waves of population remain at the present hour.

To attempt a solution of this question, it is necessary to take a wider area than that afforded by an island adjoining the north-west of Europe, but which presents the remarkable peculiarity of having been in all probability the last resting-place of a section of that great Aryan or Indo-European race which spread from the Euphrates to the Polar regions.

In tracing the footprints of man we have, as I have already stated, to consider the relics he left in the various countries which he trod, the vestiges of his language, and the physical and psychological characteristics still attaching to his modern representatives. In so doing we must consider the dim traditions, genealogies, heroic and bardic tales, rhymes, legends, religions, popular superstitions, folk-lore, romances, and all that description of knowledge which has been handed down from times denominated Prehistoric to the present day.

These traditions were in process of time embalmed in annals when the art of writing became known, along with the genealogy, the tale, or historic incident, in either prose or rhyme, which had been recited by especially instructed and, let me add, specially gifted orders of people from age to age. So the Assyrian characters cut or embossed on stone or brick preserved the records of conquests. So the 'Iliad' and the 'Odyssey' were no doubt orally transmitted long before letter-words were inscribed upon the bark, the palm-leaf, the papyrus, the waxen tablet, or the vellum. They were thus kept alive in the minds of the people, and largely helped to preserve the Greek language until it performed one of its greatest duties, nearly nineteen centuries ago, in the wide-spread diffusion of the records of Christianity.

There was a time when a large portion of the plains and non-mountainous parts of Europe were tangled forests traversed by great rivers running generally towards the south and west. According to Norwegian authorities, the Lapps were the primeval race on our Continent, and were driven northward by each successive wave of population that, creeping round the shores of the Caspian, the Black Sea, and the Mediterranean, or passing out between the hills of Ceuta and Gibraltar (then called the "Pillars of Hercules"), came along the shores of Spain, Gaul, and Belgium.

That the skin-clad man with his stone, bone, and wooden weapons and tools, his

shell ornaments and rude unglazed pottery (the primitive nomadic hunter and fisher) arrived in Ireland and occupied its plains, forests, and fastnesses in that same state of life in which we find similar primitive races of mankind in the present day,—here contending with the bear, the wolf, the fox, the osprey, the seal, and the otter for his food, as his predecessors did with the auroch in mid-Europe,—I have not the slightest doubt. I think the reindeer and the elephant, and probably the musk-ox, had become extinct before man's arrival in Erinn, and I have always inclined to the idea that he was not contemporaneous with that great monarch of the cervine race, the Irish Elk; but in this opinion, however, I may be mistaken.

Standing on the coast of Great Britain he could, with the practised eye of the hunter, have discerned from the Welsh mountains the hills of Erinn; and he could have clearly seen Donaghadee from Port Patrick.

But whether he came adrift upon a plank or raft, or in a singlestick canoe, is more than I can even speculate upon. That there were inhabitants in Ireland at the time of the arrival of these first *recorded* colonists I have but little doubt. Whether these or subsequent races were the men who erected the Lacustrine habitations, the *Pfahlbouten* of Switzerland, and their analogues the *Cranogues* of Ireland, or banqueted in the *Kitchen-middens* of Jutland, requires a further investigation of their remains.

With these rather lengthened preliminary remarks, which I thought necessary for the information of strangers, or those not specially acquainted with the subject, it is now my particular province to tell you something of the early races of the land we live in, and their representatives still existing among its present population. With respect to the authenticity of the early chronicles and legends that relate the history of these immigrations—so much sneered at by one set of inquirers and so faithfully believed in by another—let me make two observations, one chronological and the other topographical. Our Irish Annals were first committed to writing by Christian scribes in either Gaelic or Latin, and were not only intermixed with classic story, but with scriptural incidents, particularly those relating to the dispersion of mankind after the deluge. Of a portion of their chronology there can, however, be little doubt; for in recording cosmical phenomena, such as eclipses of the sun or moon, the approach of comets and the like, they scarcely differ by a year from that great astronomical and chronological work, '*L'Art de vérifier les dates*,' computed by the French philosophers hundreds of years after those Annals were last written or transcribed. This synchronism, to say the least of it, is remarkably confirmative of those very early Irish Annals. It is just possible that long before the age of alphabetic writing some means by tallies, runes, or other devices may have been invented for fixing the ages of these cosmical phenomena.

Now the other incident is of equal authenticity in confirmation of the historical statement of our early records. Long, long before the Christian era it is there said that a battle took place on a certain plain in Mayo; and an incident connected with the fight is thus told:—A king or chief was surprised in early morning, while performing his ablutions at a deep well, by three warriors of the enemy, who came upon him unawares. He was saved by the prowess of one of his attendants, who killed his three assailants, and then died upon the spot. Hundreds of years passed by, the locality around had been cultivated and grazed upon again and again; still the valley, the well, the subterranean watercourse with its fairy legends, the hurling-field, the cairns, circles, pillar-stones, and other surrounding topographical features remained. The gallant soldier who laid down his life for his royal master was buried where he fell; and as the army (stated to have been thousands strong) passed by, each man—as was the custom of the day—threw a pebble on his grave, then called and still known as "The cairn of the one man." Not long ago, with the written legend in my hand, and possessing a full knowledge of the locality, and accompanied by a few stalwart Connaught men, I proceeded to the spot, told my incredulous auditory the tale of their ancestors, dug and lifted stone after stone until we came upon a small chamber under a large flag, wherein we found deposited a beautiful cinerary urn containing some black earth and fragments of burnt human bones. The sepulchre, with its surrounding stone circle,

still exists on the battle-field of Moytura Conga, and the decorated urn is in the Museum of the Royal Irish Academy.

It has been objected to our Irish manuscripts that, from the material on which they were written, the form of their letters, their philological construction, and their illuminations, none of them was written earlier than the ninth or tenth century; some, indeed, go so far as to say that there is not an Irish MS. later than the twelfth or thirteenth century. Now granting all that, what does it prove? Not that the historic instances recorded were concocted by the scribes of these times, but that these vellum or paper manuscripts were copied from earlier writings which were founded on anterior materials. That they were interpolated, glossed, and changed in many instances from century to century in process of transcription from the time they were first committed to writing, is but a repetition of what has occurred in other countries. But, even in more modern and so-called civilized times, has not history been falsified to please the pride of a ruler or to pander to the prejudice of a party? Where, I would ask, are the early rolls of "The Law?" Where are the original manuscripts relating to or after the first century of the Christian era? Where, except in Egypt (that great land of embalmment) or at Nineveh, do we find a bit of writing two thousand years old? Are not learned artists and philologers even now disputing as to the dates of the Psalter of Utrecht and the Codex of Upsala?

To my surprise Mr. James Fergusson, in discussing the subject of our Irish histories, at p. 197 of his valuable book on 'Rude Stone Monuments,' says, when alluding to the battles of Moytura,—"Before the introduction of writing into a country, how long could so detailed a narrative as that which we possess, and one so capable of being verified by material evidences on the spot, be handed down orally as a plain prose narrative?" Surely my friend does not deny the vocal tradition of history by means of memory; and if he merely objects to the accounts of the battle of Moytura and other Irish tales from their being in prose, it is right for him to know that they are *not* all in prose, but partly in the rhythmical style of the period. The introduction of prose at the time of the use of letters can be accounted for by the fact that when the Schannaghie or rhymer found "a hole in the ballad," he supplied the legend in a prose version to the scribe, or that the scribe shortened the narrative by a prose version of his own.

Passing over, as probably apocryphal, the old tales related in the bardic legends of the Lady Kaisar and her ships, we come to Parthalon, the great Grecian hero, who landed in Dublin Bay, and whose cohorts conquered the aborigines, as related by the annalists. I should not have introduced him, but that there is a remarkable confirmation of the legend afforded by the topographic and antiquarian examination of the locality. This invader and his followers occupied, it is said, Ben-Eider, now called the "Hill of Howth," and the "old plain of the valley of the Flocks," along the shores of Dublin Bay, styled "the Strand of the Birds," passing all round from Belscadden to Bray Head; and who had, no doubt, a "Pale" for themselves as others had in later times.

A *Thaum* or pestilence attacked that people, and they are said to have *all* died. Upon the age of this catastrophe, or the numbers who died of it, I cannot speculate; but I believe that when flying from the seacoast and plains to the mountains a large number perished and were buried on the slopes of Tallaght, so called because it was the *Thaum-Lacht* where the plague-stricken people were interred, and where occasionally Kistvaens are turned up containing decorated urns, having within them incinerated bones. Several of these are still in existence; and when I stand at the northern end of this great plain of Dublin, said to have been colonized by Parthalon, my foot is on his reputed cromleach at Ben-Eider.

Of the Femorians, Nemedians, and other minor invaders we need take no notice, as they have left nothing after them by which to track their footprints. The annalists, or at least the transcribers, probably believed that these people all came direct from the Ark, after resting for a while on Mount Ararat, or that they were descended direct from Japhet, or from Gog and Magog. Cuthites were not known here then.

I will now tell you what has been the result of my own examination of the races that migrated to, or are said to have conquered, Ireland.

A pastoral people called Firbolgs, said to be of Greek or Eastern origin, and probably a branch of that race that, having passed through Europe or round its shores, arrived in Ireland. We will call them Celts, as I do not know much of the Phœnicians or Carthaginians. They had laws and social institutions, and established a monarchical government at the far-famed Hill of Tara, about which our early centres of civilization sprung, and around which we have now most of those great pasture-lands which, notwithstanding this island being described as "a marsh saturated with the vapours of the Atlantic" and "surrounded by a melancholy ocean," on the shore of which the wretched inhabitant might sit and sigh for the time of his exodus and the hour of his exile—these plains of Meath that can beat the world for their fattening qualities, and supply neighbouring countries with their most admired meats.

I cannot say that the Firbolg was a cultivated man, but I think he was a shepherd and an agriculturist. I doubt if he knew any thing, certainly not much, of metallurgy; but it does not follow that he was a mere savage, no more than the Maories of New Zealand were when we first came in contact with them.

The Firbolgs were a small, straight-haired, swarthy race, who have left a portion of their descendants with us to this very day. A genealogist (their own countryman resident in Galway about two hundred years ago) described them as dark-haired, talkative, guileful, strolling, unsteady, "disturbers of every Council and Assembly," and "promoters of discord." I believe they, together with the next two races about to be described, formed the bulk of our so-called Celtic population—combative, nomadic on opportunity, enduring, litigious, but feudal and faithful to their chiefs; hard-working for a spurt (as in their annual English emigration); not thrifty, but, when their immediate wants are supplied, lazy, especially during the winter.

To these physical and mental characters described by MacFirbis let me add those of the unusual combination of blue or blue-grey eyes and dark eyelashes with a swarthy complexion. This peculiarity I have only remarked elsewhere in Greece; the mouth and upper gum is not good, but the nose is usually straight. In many of this and the next following race there was a peculiarity that has not been alluded to by writers—the larynx, or, as it used to be called, the *pomum Adami*, was remarkably prominent, and became more apparent from the uncovered state of the neck. The sediment of this early people still exists in Ireland, along with the fair-complexioned Dannans, and forms the bulk of the farm-labourers, called in popular phraseology *Spalpeens*, that yearly emigrate to England. In Connaught they now chiefly occupy a circle which includes the junction of the counties of Mayo, Galway, Roscommon, and Sligo. They, with their fair-faced brothers (at present the most numerous), are also to be found in Kerry and Donegal; and they nearly all speak Irish.

By statistics procured from our Great Midland Western Railway alone, I learn that on an average 30,000 of these people, chiefly the descendants of the dark Firbolgs and fair Dannans, emigrate annually to England for harvest work, to the great advantage of the English farmer and the Irish landlord. The acreage of arable land for these people runs from two to six acres.

Connecting this race with the remains of the past, I am of opinion that they were the first rath or earthen-mound and enclosure makers; that they mostly buried their dead without cremation, and, in cases of distinguished personages, beneath the Cromleach or the Tumulus. Their heads were oval or long in the antero-posterior diameter, and rather flattened at the sides: examples of these I have given and descanted upon when I first published my Ethnological Researches, which have been fully confirmed by the late Andreas Retzius. It is, however, unnecessary, even if space or advisability permitted, for me to allude to such matters, as that great work the 'Crania Britannica' has lithographed typical specimens of this long-headed race.

The next immigration we hear of in the 'Annals' is that of the *Tuatha-de-Dannans*, a large, fair-complexioned, and very remarkable race; warlike, energetic, progressive, skilled in metal work, musical, poetical, acquainted with the healing art, skilled in Druidism, and believed to be adepts in necromancy and magic, no doubt the result of the popular idea respecting their superior knowledge, especially in smelting and

in the fabrication of tools, weapons, and ornaments. From these two races sprang the Fairy Mythology of Ireland.

It is strange that, considering the amount of annals and legends transmitted to us, we have so little knowledge of Druidism or Paganism in ancient Ireland. That, however, may be accounted for in this wise:—That those who took down the legends from the mouths of the bards and annalists, or those who subsequently transcribed them, were Christian missionaries whose object was to obliterate every vestige of the ancient forms of faith.

The Dannans spoke the same language as their predecessors, the Firbolgs. They met and fought for the sovereignty. The "man of metal" conquered and drove a great part of the others into the islands on the coast, where it is said the Firbolg or Belgic race (so called) took their last stand. Eventually, however, under the influence of a power hostile to them both, these two peoples coalesced, and have to a large extent done so up to the present day. They are the true old Irish peasant and small farming class.

The Firbolg was a bagman, so called, according to Irish authorities, because he had to carry up clay in earthen bags to those terraces in Greece now vine-clad. As regards the other race there is more difficulty in the name. Tuath or Tuatha means a tribe or tribe-district in Irish. Dannan certainly sounds very Grecian; and if we consider their remains, we find the long, bronze, leafed-shaped sword, so abundant in Ireland, identical with weapons of the same class found in Attica and other parts of Greece.

Then, on the other hand, their physiognomy, their fair or reddish hair, their size, and other circumstances incline one to believe that they came down from Scandinavian regions after they had passed up as far as they thought advisable into North-western Europe. If the word Dane was known at the time of their arrival here, it would account for the designation of many of our Irish monuments as applied by Molyneux and others. Undoubtedly the Dannan tribes presented Scandinavian features, but did not bring any thing but Grecian art. After the "Stone period," so called, of which Denmark and the south of Sweden offer such rich remains, I look upon the great bulk of the metal work of the North, especially in the swords in the Copenhagen and Stockholm Museums, as Asiatic; while Ireland possesses not only the largest native collection of metal weapon-tools, usually denominated "celts," of any country in the world, but the second largest amount of swords and battle-axes. And moreover these, and all our other metal articles, show a well-defined rise and development from the simplest and rudest form in size and use to that of the most elaborately constructed and the most beautifully adorned.

I believe that these Tuatha-de-Dannans, no matter from whence they came, were, in addition to their other acquirements, great masons, although not acquainted with the value of cementing materials. I think they were the builders of the great stone Cahirs, Duns, Cashels, and Caves in Ireland; while their predecessors constructed the earthen works, the raths, circles, and forts that diversify the fields of Erinn. The Dannans anticipated Shakespeare's grave-digger, for they certainly made the most lasting sepulchral monuments that exist in Ireland, such, for example, as New Grange, Douth, Knowth, and Slieve na Calleagh and other great cemeteries. Within the interior and around these tombs were carved, on unhewn stones, certain archaic markings, spires, volutes, convolutes, lozenge-shaped devices, straight, zigzag, and curved lines, and incised indentations, and a variety of other insignia, which, although not expressing language, were symbolical, and had an occult meaning known only to the initiated. These markings, as well as those upon the urns, were copied in the decorations of the gold and bronze work of a somewhat subsequent period. The Dannans conquered the inferior tribes in two celebrated pitched battles, those of the Northern and Southern Moytura. On these fields we still find the caves, the stone circles, the monoliths, and dolmens or cromleachs that marked particular events, and the immense cairns that were raised in honour of the fallen chieftains.

Although many of the warriors of the Firbolgs fled to their island fastnesses on the coasts of Galway and Donegal, no doubt a large portion of them remained in the inland parts of the country, and in that very locality to which I have adverted, which is almost midway between the sites of the two battles, in a line stretching

between Mayo and Sligo, where in time the two races appear to have coalesced by that natural law which brings the dark and the fair together.

Moreover it has been recorded that the conquering race sent their small dark opponents into Connaught, while they themselves took possession of the rich lands further east, and not only established themselves at Tara but spread into the south. It is remarkable that in time large numbers of the Dannans themselves were banished to the West, and likewise that the last forcible deportation of the native Irish race (so late as the seventeenth century) was when the people of this province got the choice of going "to Connaught or Hell," in the former of which, possibly, they joined some of the original stock. The natural beauty of the lakes and mountains of Connaught remains as it was thousands of years ago; but no doubt if some of the legislators of the period to which I have already referred could now behold its fat pasture-plains, they might prefer them to the flax lands of Ulster.

These Dannans had a globular form of head, of which I have already published examples. For the most part I believe they burned their dead or sacrificed to their manes, and placed an urn with its incinerated contents—human or animal—in the grave, where the hero was either stretched at length or crouched in an attitude similar to that adopted by the ancient Peruvians, as I have elsewhere explained. These Irish urns, which are the earliest relics of our ceramic art that have come down to the present time, are very graceful in form, and some of them most beautifully decorated, as may be seen in our various museums.

Specimens of this Dannan race still exist, but have gradually mixed with their forerunners to the present day. Here is what old MacFirbis wrote of them two hundred years ago:—"Every one who is fair-haired, vengeful, large, and every plunderer, professors of musical and entertaining performances, who are adepts of druidical and magical arts, they are the descendants of the Tuatha-de-Dannans." They were not only fair but sandy in many instances, and consequently extensively freckled.

It is affirmed that the Dannans ruled in Ireland for a long time, until another inroad was made into the island by the Milesians—said to be brave, chivalrous, skilled in war, good navigators, proud, boastful, and much superior in outward adornment as well as mental culture, but probably not better armed than their opponents. They deposed the three last Dannan kings and their wives, and rose to be, it is said, the dominant race—assuming the sovereignty, becoming the aristocracy and landed proprietors of the country, and giving origin to those chieftains that afterwards rose to the title of petty kings, and from whom some of the best families in the land with any thing like Irish names claim descent, and particularly those with the prefix of the "O" or the "Mac." When this race arrived in Ireland I cannot tell, but it was some time prior to the Christian era. It is said they came from the coast of Spain, where they had long remained after their eastern emigration.

Upon the site of what is believed to be the ancient Brigantium, now the entrance to the united harbours of Corunna and Ferrol, stands the great lighthouse known to all ships passing through the Bay of Biscay. Within this modern structure still exists the celebrated "Pharos of Hercules," which I investigated and described many years ago. That tower, it was said in metaphorical language, commanded a view of Ireland, and as such became the theme of Irish poems and legends. Certain it is that sailing north or north-westward from it the ships of the sons of Milesius and their followers could have reached Ireland without much coasting. If the story of Breogan's Tower is true, then it must have been erected in the time of lime-and-mortar building, and that is during the Roman occupation of Iberia and Gaul. How many thousands, rank and file, of these Spanish Milesians came here in their six or eight galleys and tried the fortunes of war from "the summit of the ninth wave from the shore" and conquered the entire Dannan, Firbolg, and Femorian population, I am unable to give the slightest inkling of, no more than I can of the so-called Phœnician intercourse with this country. Perhaps without going into the fanciful descriptions of the "Battle of Ventry Harbour," or the Southern conquest of Ireland by the Iberian Milesians, we may find some more trustworthy illustrations of Spanish dwellings in the architecture of the town of Galway, and some picturesque representatives in the lithe upright figures and raven-

haired, but blue-eyed maidens of the City of the Tribes. Here is what old MacFirbis, who, I suppose, claimed descent from the sons of Milesius, wrote about them:—"Every one who is white of skin, brown of hair, bold, honourable, daring, prosperous, bountiful in the bestowal of property, and who is not afraid of battle or combat, they are the descendants of the sons of Milesius in Erin."

This high panegyric is only equalled by the prose and verse compositions of the ancient bards and rhymers and the modern historians, who have recorded the deeds of the great warriors, Ith, Heber, and Heremon, whose descendants boast to have been the rulers of the land. Even Moore, although he wrote such beautiful lyrics concerning this race in his early days, yet when he came to study history he felt the same difficulty I do now. I do not dispute their origin or supremacy; but I fail to distinguish their early customs, their remains, or race from those of the Filbolgs or Dannans whom they conquered, and who left undoubted monuments peculiar to their time.

Now all these peoples—the piratical navigator along our coasts, the mid-Europe primitive shepherd and cultivator, the Northern warrior, and the Iberian ruler—were, according to my view, all derived from the one Celtic stock. They spoke the same language, and their descendants do so still. When they acquired a knowledge of letters they transmitted their history through the Irish language. No doubt they fused; but somehow a quick fusion of races has not been the general characteristic of the people of this country. Unlike the Anglo-Norman in later times, the Milesian was a long way from home; the rough sea of the Bay of Biscay rolled between him and his previous habitat; and if he became an absentee he was not likely to find much of his possessions on his return. It is to be regretted that while we have here such a quantity of poetical and traditional material respecting the Milesian invasion of Ireland, the Spanish annals or traditions have given us but very little information on that subject.

It would be most desirable if the Government or some Irish authority would send a properly instructed commissioner to investigate the Spanish annals, and see whether there is any thing relating to the Spanish migrations to Ireland remaining in that country.

Besides the sparse introduction of Latin by Christian missionaries in the fifth century, some occasional Saxon words springing from peaceful settlers along our coasts and in commercial emporiums, and whatever Danish had crept into our tongue around those centres where the Scandinavians chiefly located themselves, and which were principally proper names of persons and places that became fixed in our vernacular, we find but one language among the Irish people until the arrival of the Anglo-Normans at the end of the twelfth century.

The linguistic or philological evidence on this subject is clearly decisive. The residue of the early races already described spoke one language, called Gaelic; so did the Scotch, the Welsh, and probably, in early times, the Britons and the Bretons. It was not only the popular conversational tongue used in the ordinary intercourse of life, but it was also employed in genealogies, annals, and other records in a special character, not quite peculiar to this country, but then common in Europe. Much has been said about the necessity for a glossary of our ancient MSS., such as those at Saint Gall, in Trinity College, in the Royal Irish Academy, and in Belgian and English libraries; but there are very few ancient languages that do not require to be glossed in the present day, even as the words of Chaucer do.

The Government are now, under the auspices of our Master of the Rolls, and the special direction and supervision of Mr. J. T. Gilbert, giving coloured photographs of some of our ancient writings, and have promised that some of our remaining manuscripts will be translated. I see no occasion now for waiting for more elaborated philological dictionaries or glossaries while there are still some few Irish scholars in the country capable of giving a free but tolerably literal translation of these records that do not require any great acumen in rendering them into English. Is history to wait upon the final decision of philologists respecting a word or two in a manuscript, and decide as to whether it may be of Sanscrit or any other origin?

No doubt some of my hearers may ask,—What about the Oghams (or Ohams)? do they not show a very early knowledge of an alphabet? As yet this is a moot

question. A rude pillar-stone, having upon it a tolerably straight edge, was in early times notched along its angle which served as a stem-line, by nicks formed on it, and straight or oblique lines, singly or in clusters, proceeding from the stem. The decipherers of these inscriptions have, one and all, agreed upon the fact that these lines represented letters, syllables, or words, and that the language is either Irish or Latin. Therefore the persons who made them must have been aware of alphabetic writing and grammar. These carved monoliths are chiefly found in Kerry and Cork. Upon some of them Christian emblems are figured. The incising of the stone has evidently been performed by some rude instrument, either a flint or metallic pick; and it is remarkable that these pillars present scarcely any amount of dressing.

In Connaught, in my youth, the exception in remote districts was where the person spoke *both* English and Irish. In 1851, when we first took a Census of the Irish-speaking population, after the country had lost three-quarters of a million of people, chiefly of the Irish race, we had then (to speak in round numbers) one and a half million of Irish-speaking population. In 1861 they had fallen off by nearly half a million; and upon the taking of the last Census in 1871 the entire Irish-speaking population was only 817,865. The percentages, according to the total population in our different provinces, were these:—In Leinster 1·2, in Munster 27·7, in Ulster 4·6, and in Connaught 39·0; for the total of Ireland 15·1. Kilkenny and Louth are the counties of Leinster where the language is most spoken. In Munster they are Kerry, Clare, and Waterford; in Ulster, Donegal, where 28 per cent. of the population speak Irish; but in Connaught, to which I have already alluded as containing the remnant of the early Irish races, we have no less than 56 per cent. of Irish-speaking population in the counties of Mayo and Galway respectively. Of my own knowledge I can attest that a great many of these people cannot speak English. We thus see that of the population of Ireland, which in the present day might be computed at about five and a half millions, there were, at the time of taking the census in April 1871, only 817,865; and I think I may prophecy that that is the very largest number that in future we will ever have to record. On the causes of this decadence it is not my province to descant. These Celts have been the great pioneers of civilization, and are now a power in the world. Are they not now numerically the dominant race in America? and have they not largely peopled Australia and New Zealand?

We have now arrived at a period when you might naturally expect the native annalist to make some allusion to conquest or colonization by the then mistress of the world. Without offering any reason for it, I have here only to remark that neither as warriors nor colonizers did the Romans ever set foot in Ireland; and hence the paucity of any admixture of Roman art amongst us.

To fill up a hiatus which might here occur in our migrations, I will mention a remarkable circumstance. A Christian youth of Romano-Saxon parentage, and probably of Patrician origin, was carried off in a raid of Irish marauders, and employed as a swine-herd in this very Ulster, the country of the Dalaradians, and lived here for several years, learning our customs and speaking our language. He escaped, however, to Munster, and thence to his native land of Britain or Normandy, from whence he returned in A.D. 432 with friends, allies, and missionaries, and passing in his galley into the mouth of the Boyne, walked up the banks of that famed stream, raised the paschal fire at Slane, and speedily introduced Christianity throughout Ireland.

In thus briefly alluding to the labours of St. Patrick, I wish to be understood to say that about the time of his mission there was much Saxon intercourse with this country, and the great missionary had not only many friends but several relatives residing here, and some of them on the very banks of the Boyne; and I believe that a considerable amount of civilization and some knowledge of Christianity had been introduced long previously; so that, although old King Laoghaire or Loury and his Druids did not bow the knee to the Most High God, nor accept the teaching of the beautiful hymn that Patrick and his attendants chanted as they passed up the grassy slopes of Tara, still there were many hundred people in Ireland ready to receive the glad tidings of the gospel of salvation.

Having finished with the Milesians, we now come to the Danes (so called), the

Scandinavians or Norsemen—The Pagan Sea-Kings who made inroads on our coasts, despoiled our churches and monasteries, but at the same time, it must be confessed, helped to establish the commercial prosperity of some of our cities and towns from 795 to the time of the battle of Clontarf, A.D. 1014, when the belligerent portion of the Scandinavians were finally expelled the country. During the time I have specified, Dublin, Limerick, and Waterford belonged to these northern people. They not only coasted round the island and never lost an opportunity of pillage and plunder, but they passed through the interior and carried their arms into the very centre of the land. The Danes left us very little ornamental work beyond what they lavished upon their swords and helmets; but, on the other hand, it should be borne in mind that there are no Irish antiquities, either social, warlike, or ecclesiastical, in the Scandinavian Museums.

Concerning their ethnological characters I must again refer to the 'Crania Britannica.' In the records they were designated strangers, foreigners, pagans, gentiles, and also white and black foreigners; so that there were undoubtedly two races—the dark, and the fair or red, like as in the case of the Firbolgs or Dannans. They were also styled "Azure Danes," probably on account of the shining hue of their armour.

I believe the fair section of that people to have been of Norwegian origin, while the dark race came from Jutland and the coast of Sweden; and both by the Orkneys, the coasts of Scotland, and the Isle of Man. Their skulls were large and well-formed; they had a thorough knowledge of metal work, and especially iron; and, as I have shown elsewhere, their swords and spears were of great size and power, the former wielded as a slashing-weapon, while those of their early opponents were of bronze, weak, and intended for stabbing. In nowhere else in Europe (that I am aware of) have these rounded, pointed, or bevelled heavy iron swords been found except in Ireland and Norway.

Large quantities of Danish remains have been discovered in deep sinkings made in Dublin; and several weapons, tools, and ornaments, believed to be of Scandinavian origin, have been found within a few inches of the surface on one of the battle-fields on the south side of the Liffey, within the last few years. Upon most of these I have already reported and given illustrations. I may mention one circumstance connected with this race. I never examined a battle-field of the Danes, nor a collection of Danish weapons or implements, that I did not find the well-adjusted scales and weights which the Viking had in his pocket for valuing the precious metals he procured either by conquest or otherwise.

Although considered hostile, these Scandanavians Vikings must have fraternized with the Irish. We know that they intermarried; for, among many other instances that might be adduced, I may mention that during the battle of Clontarf, when Sitric, the Danish king of Dublin, looked on the fight from the walls of the city, he was accompanied by his wife, the daughter of the aged king, known as "Brian the Brave."

When, however, the Irish chieftains were not fighting with one another, they were often engaged in petty wars with the Scandinavians, who, in turn, were attacked by their own countrymen, the "Black Gentiles," especially on the plain of Fingall, stretching from Dublin to the Boyne, and which the white race chiefly occupied. It must not be supposed that the battle of Clontarf ended the Danish occupation of Ireland; they still held the cities of Dublin, Limerick, and Waterford at least, and largely promoted the commercial prosperity in these localities—a prosperity which has not yet quite departed. I should like to present you with some remains of the Scandinavian language, but the materials are very scanty.

We are now coming to a later period. The Romans had occupied Britain, the Saxons followed; the Danes had partial possession for a time; the Heptarchy prevailed, until Harold, the last of the Saxon kings, fell at Hastings, and England bowed beneath that mixture of Norman, Gaulish, Scandinavian, and general Celtic blood that William brought with him from the shores of France. The Saxon dynasty was at an end, but the Britons of the day accepted their fate; and not only the soldiers, but the Norman Barons fused with the people of that kingdom, and largely contributed to make it what it now is. This fusion of races, this assimilation of sentiments, this interchange of thought, this kindly culture,

the higher elevating the lower, among whom they have permanently resided, must always tend to great and good ends in raising mankind to that state into which I hope it will yet please Providence to call him.

I must hasten on. The Anglo-Normans came here in 1172, a very mixed race, but their leaders were chiefly of French or Norman extraction. Why they came, or what they did, it is not for me to expatiate upon. I wish, however, to correct an assertion commonly made, to the effect that the Norman barons of Henry II. *then* conquered Ireland. They occupied some towns, formed a "Pale," levied taxes, sent in soldiery, distributed lands, and introduced a new language; but the "King's writ did not run;" the subjugation of Ireland did not extend over the country at large, and it remained till 1846 and the five or six following years to complete the conquest of the Irish race, by the loss of a tuberous esculent and the governmental alteration in the value of a grain of corn. Then there went to the workhouse or exile upwards of two millions of the Irish race, besides those who died of pestilence. Having carefully investigated and reported upon this last great European famine, I have come to the conclusion just stated, without taking into consideration its political, religious, or national aspects, so far as this communication is concerned.

It appears to me that one of our great difficulties in Ireland has been the want of fusion—not only of races, but of opinions and sentiments, in what may be called a "give and take" system. As regards the intermixture, I think there cannot be a better one than the Saxon with the Celt. The Anglo-Normans, however, partially fused with the native Irish; for Strongbow married Eva the daughter of King Dermod; and from this marriage it has been clearly shown that Her Most Gracious Majesty the present Queen of Ireland and Great Britain is lineally descended. Several of the noble warriors who came over about that period have established great and wide-spread names in Ireland, among whom (not to be tedious) I may mention the Geraldines in Leinster, the De Burgos in Connaught, and the Butlers in Munster, as is manifest from the name-rolls of the country; and they and their descendants became, according to the old Latin adage, "more Irish than the Irish themselves."

Look what the intermixture of races has done for us in Ireland; the Firbolg brought us Agriculture; the Dannan the chemistry and mechanics of metal work; the Milesians beauty and governing power; the Danes commerce and navigation; the Anglo-Normans chivalry and organized government; and, in later times, the French emigrants taught us an improved art of weaving.

It would be more political than ethnological were I to enter upon the discussion of that subsequent period which would conduct us to the days of Cromwell or the Boyne, or, perhaps, to later periods, involving questions not pertinent to the present occasion.

I must here say a word or two respecting Irish art. In architecture, in decorative tone-work, from archaic markings that gave a tone and character to all subsequent art, in our beauteous crosses, in our early metal work, in gold and bronze, carried on from the Pagan to the Christian period, and in our gorgeously illuminated MS. books, we have got a style of art that is specially and peculiarly Irish, and that has no exact parallel elsewhere, and was only slightly modified by Norman or Frankish design.

Time passed, as it is passing now, and events accumulated; political affairs intermingle, but the anthropologist should try and keep clear of them. At the end of the reign of Elizabeth a considerable immigration of English took place into the south of Ireland. Subsequently the historic episode of the "Flight of the Earls," O'Neill and O'Donnell, brought matters to a climax; and the early part of the reign of the first James is memorable for the "Plantation of Ulster," when a number of Celtic Scots with some Saxons returned to their brethren across the water; and about the same time the London companies occupied large portions of this fertile province, and the early Irish race were transplanted by the Protector to the West, as I have already stated. It must not be imagined that this was the first immigration. The Picts passed through Ireland and no doubt left a remnant behind them. In consequence of contiguity, the Scottish people must early have settled upon our northern coasts. When the adventurous Edward Bruce made that marvellous

inroad into Ireland at the end of the fourteenth century and advanced into the bowels of the land, he carried with him a Gaelic population cognate with our own people, and in all probability left a residue in Ulster, thus leavening the original Firbolgs, Tuatha-de-Dannan, and Milesians, with the exception of the County of Donegal, which still holds a large Celtic population speaking the old Irish tongue, and retaining the special characters of that people as I have already described them. This Scotic race, as it now exists in Ulster, and of which we have specimens before us, I would sum up with three characteristics. That they were courageous is proved by their shutting the gates and defending the walls of Derry; that they were independent and lovers of justice has been shown by their establishment of tenant-right; and that they were industrious and energetic is manifest by the manufactures of Belfast. Do not, I entreat my brethren of Ulster, allow these manufactures to be jeopardized, either by masters or men, by any disagreements, which must lead to the decay of the fairest and wealthiest province and one of the most beautiful cities in this our native land.

BOTANY.

[For Dr. Hooker's Address see page 102.]

Note on Variation of Leaf-Arrangement. By HUBERT AIRY, *M.D.*

Approaching the problem of leaf-arrangement from a Darwinian point of view, it is important to observe the variations which arise at the present day in the disposition of leaves in different individuals of the same species; for it is reasonable to suppose that variations of the same kind have arisen also in former ages, and the problem would be solved if we could see that the accumulative tendency of such variations (starting from some simple form of leaf-arrangement) would naturally result in the production of all the complex forms of leaf-arrangement which now exist.

The chief general feature of leaf-arrangement being the disposition of leaves in parallel ranks, vertical or spiral as the case may be, the variations which present themselves at the present day are of two kinds:—

First, there are variations in the *number* of leaf-ranks.

Second, there are variations in the *obliquity* of ranks, their number remaining the same.

The object of this paper is especially to put on record some observations which illustrate the first of these two kinds of variation.

(1) Examples of variation of *number* of leaf-ranks.

Name of plant and part examined.	Number of specimens with same arrangement.	Number of conspicuous ranks of leaves.	Character of ranks (vertical or spiral).	Phyllotactic fraction.
Knautia arvensis (head).	2 specimens had	10 & 16 conspicuous spiral ranks, ten one way and sixteen the other.	Spiral.	This arrangement is that which would result from condensation of the crucial arrangement of the stem-leaves.—Call it *a*.
	1 specimen had	8 & 13.	"	Near $\frac{8}{21}$.
Total	3			

Name of plant and part examined.	Number of specimens with same arrangement.	Number of conspicuous ranks of leaves.	Character of ranks (vertical or spiral).	Phyllotactic fraction.
Scabiosa succisa (head).	20 specimens had	6, 10, & 16.	Spiral.	*a.* (See note to *Knautia arvensis* above.)
	8 „	5, 8, & 13.	„	Near $\frac{8}{21}$.
	2 „	4, 7, & 11.	„	Near $\frac{5}{18}$.
	1 specimen had	9.	„	Near $\frac{3}{14}$.
	7 specimens	irregular.		
Total	38			
Scabiosa columbaria (head).	6 specimens had	6, 10, & 16.	Spiral.	*a.*
	13 „	5, 8, & 13.	„	Near $\frac{8}{21}$.
	5 „	8 & 12.	„	? Condensed from whorls of 4.
	1 specimen had	10.	„	*a.*
	1 „	4 & 7.	„	Near $\frac{3}{11}$.
	1 „	irregular.		
Total	27			
Leontodon taraxacum (head).	92 specimens had	8, 13, 21, & 34.	Spiral.	Near $\frac{13}{34}$.
	4 „	16 & 26.	„	*a.*
	2 „	18 & 29.	„	Near $\frac{8}{29}$.
	2 „	irregular.		
Total	100			
Erica tetralix (stem).	144 specimens had	8.	Vertical.	4-whorled.
	2 „	7.	Spiral.	Near $\frac{2}{7}$.
	9 „	6.	Vertical.	3-whorled.
	4 „	10.	„	5-whorled.
	1 specimen had	9.	Spiral.	Near $\frac{2}{9}$.
Total	160			
Erica cinerea (stem).	75 specimens had	6.	Vertical.	3-whorled.
	2 „	7.	Spiral.	Near $\frac{2}{7}$.
	2 „ {	6.	Vertical.	3-whorled.
		7.	Spiral.	Near $\frac{2}{7}$.
		8.	Vertical.	4-whorled.
	1 specimen had {	6.	„	3-whorled.
		7.	Spiral.	Near $\frac{2}{7}$.
Total	80			
Verbena officinalis (spike).	97 specimens had	3 & 5.	Spiral.	Near $\frac{2}{5}$.
	11 „	4 & 7.	„	Near $\frac{2}{7}$.
	2 „	4 & 6.	„	*a.*
	1 specimen had	4, 5, & 9.	„	Near $\frac{2}{9}$.
	1 „ {	8.	Vertical.	4-whorled.
		4, 5, & 9.	Spiral.	Near $\frac{2}{9}$.
Total	112			

Name of plant and part examined.	Number of specimens with same arrangement.	Number of conspicuous ranks of leaves.	Character of ranks (vertical or spiral).	Phyllotactic fraction.
Plantago major (spike).	55 specimens had	3, 5, & 8.	Spiral.	Near $\frac{5}{13}$.
	1 specimen had	6 & 10.	,,	*a.*
Total	56			
Carex stricta (spikelet).	1 specimen had	5.	Spiral.	Near $\frac{2}{5}$.
	13 specimens had	6.	Vertical.	3-whorled.
	36 ,,	7.	Spiral.	Near $\frac{2}{7}$.
	58 ,,	8.	Vertical.	4-whorled.
	23 ,,	9.	Spiral.	Near $\frac{2}{9}$.
	7 ,,	10.	Vertical.	5-whorled.
	2 ,,	11.	Spiral.	Near $\frac{2}{11}$.
	1 specimen had	10.	,,	*a.*
	13 showed distinct change in number of ranks and arrangement.			
	1 was irregular.			
Total	155			
Carex vesicaria (spikelet).	4 specimens had	5.	Spiral.	Near $\frac{2}{5}$.
	41 ,,	6.	Vertical.	3-whorled.
	34 ,,	7.	Spiral.	Near $\frac{2}{7}$.
	7 ,,	8.	Vertical.	4-whorled.
	2 ,,	5 & 8.	Spiral.	Near $\frac{3}{8}$.
	2 ,,	9.	,,	Near $\frac{2}{9}$.
	20 showed distinct change.			
	4 were irregular.			
Total	114			
Lycopodium clavatum (stem and branches).	1 specimen had	7.	Spiral.	Near $\frac{2}{7}$.
	21 specimens had	8.	Vertical.	4-whorled.
	1 specimen had	8.	Spiral.	Near $\frac{3}{8}$.
	28 specimens had	9.	,,	Near $\frac{2}{9}$.
	16 ,,	10.	Vertical.	5-whorled.
	1 specimen had	9.	Spiral.	Near $\frac{2}{9}$.
		10.	Vertical.	5-whorled.
	68			
Cactus ——, sp.? (stem).	1 specimen had	8.	Vertical.	4-whorled.
	6 specimens had	10.	,,	5-whorled.
	2 ,,	6 & 10.	Spiral.	*a.*
	19 ,,	11.	,,	Near $\frac{2}{11}$.
	2 ,,	12.	Vertical.	6-whorled.
	8 showed distinct change.			
Total	38			

For similar facts, with respect to cones of Norway spruce, black spruce, European larch, American larch, see a paper in 'The American Naturalist,' vol. vii. no. 8, Aug. 1873, "On the Phyllotaxis of Cones," by Prof. W. J. Beal.

To the above are to be added the many common instances of plants 2-whorled (crucial) changing to a 3-whorled form, *e. g.* maple, sycamore, lilac, laurustinus, horse-chestnut, ash, elder, stinging-nettle, &c.

With these may be classed variations in the number of petals, stamens, or stigmas of a flower, such as the following:—

	Number of specimens.			
Papaver rhœas (stigmas).	3	with	7	stigmatic rays.
" "	7	"	8	"
" "	5	"	9	"
" "	18	"	10	"
" "	16	"	11	"
" "	4	"	12	"
" "	9	"	13	"
" "	3	"	14	"
Total......	65			

And if, as I suppose, the ranks of rootlets on the main root of a plant have relation (historically) to the ranks of leaves on the stem, then the following instance of variation of rootlet-order may be quoted here:—

	Number of specimens.			
Rumex crispus? (root).	1	had	2	rows of rootlets on main or branch-root.
" "	20	"	3	" "
" "	7	"	4	" "
" "	1	"	5	" "
" "	1	"	6	" "
Total......	30			

(2) Examples of variation of *obliquity* of leaf-ranks.

Gasteria carinata has normally two vertical ranks in alternate order ($\frac{1}{2}$). As a variation these two ranks are found decidedly twisted.

Plantago major shows marked variation in degree of condensation of leaf-arrangement (involving variation of obliquity of ranks).

In a paper on leaf-arrangement, of which an abstract is published in the 'Proceedings of the Royal Society' for 1874, vol. xxii. pp. 298–307, I have explained how, by the accumulative action of the above two modes of variation combined, it is possible that all the existing varieties of leaf-arrangement may have been produced.

Notes on Apothecia occurring in some Scytonematous and Sirosiphonaceous Algal Species, in addition to those previously known. By WILLIAM ARCHER.

This paper is descriptive of the apothecia and spores (with figures) found by the author in two species of *Scytonema*, two of *Sirosiphon*, and one of *Stigonema*, all of them *specifically* different from any of the few similar cases hitherto recorded. According to the older view that these are the fruits of the species of Scytonematous and Sirosiphonaceous Algæ in question, the cases brought forward, coupled with a similar fructification having been recorded in a very few other related species, would go to indicate that these so-called Algæ were not *algæ* truly but *lichens*. According to the newer view propounded by De Bary and Schwendener, all such cases would only represent so many instances of the invasion of the algæ concerned by so many distinct fungal parasites, of which the apothecia were the proper fructification.

There could be little doubt but that, *upon either view*, the five plants (either as regards the "algæ" or the "parasites") herein referred to, as well as Bornet's *Lichenosphæria* and *Spilonema* and Nylander's *Gonionema* (not to speak of *Ephebe*), are so many quite distinct species. If the apothecia are to be regarded as the "fruit" of the several forms of the *algæ* in question, even though some may externally so very closely resemble, these (algæ) must be quite distinct species *inter se*; if, on the other hand, the apothecia must be looked upon as the fruit of the

"parasite" invading the various algæ in question, in accordance with the new view, then the parasites attacking each must be mutually quite distinct species, and, taken on the whole, *marvellously* choice in their selection of "host."

Proceeding on the latter assumption, two of the forms now brought forward would have to be regarded as two "new species," falling either under the genus *Ephebella*, Itzigsohn, or *Gonionema*, Nylander. The three other forms would probably have to be referred as "new species" to *Spilonema*, or one of them, wanting paraphyses, to *Lichenosphæria*, Bornet.

For the new view much that has been advanced by its supporters is very cogent and striking, if not yet conclusive.

But in "lichens" like *Ephebella, Gonionema, Ephebe, Spilonema, Lichenosphæria*, in which it is the "alga" which builds up the outward configuration of the thallus, and which simply harbours latent within it the parasite, the latter making itself externally evident only by its exserted apothecia, does it not seem inconsistent to describe the characters of the thallus of the alga as part and parcel of those of the "lichen?" Thus Bornet, in giving the characters of *Lichenosphæria Lenormandi*, describes it generically thus:—"Thallus tenellus, ramosus, fruticulosus, fere omnino stigonematoideus, basi corticatus;" and specifically he speaks of it as "Thallus fusco-niger, tomentoso-intricatus." *This*, for so far going on the Schwendenerian view, is nothing more nor less than describing the characters of "*Sirosiphon divaricatus*, Kütz." (the plant invaded by the "parasite"); but when he goes on to describe the apothecia, the paraphyses, the spermogonia, the spores, he is giving the characters of the parasite and the real "new species."

There can be little doubt but that amongst these Scytonematous and Sirosiphonaceous Algæ quite truly distinct forms occur, but that, on the other hand, there can be almost as little doubt but that Kützing has very greatly overrated their number. Now it is hard to conceive that one and the same parasite would care very much *which* of forms so closely resembling it invaded in order to pursue its course of life. *Sirosiphon divaricatus* seems not to differ much from *S. alpinus* (one of those now brought forward with apothecia): now what very perceptible barrier is there to the supposition that the parasite which invades the former to form *Lichenosphæria Lenormandi*, Bornet, might not at another time invade the latter? Would it *then* fructify in the same way, show spores alike, &c.? But the "parasite" which does really invade the latter (as shown by this paper) is *not* the *same*. Are these Scytonemicolous and Sirosiphonicolous parasites, then, so extremely choice?

Again, two very closely allied forms of *Scytonema* now brought forward likewise showed very distinct parasites, as evinced by their spores, whilst those of one of them much resembled that of *Sirosiphon pulvinatus*, an alga in itself sufficiently unlike the other.

In objection to the new theory, though it has much to say for itself, in the mean time and whilst it is, as it were, on its trial, it might be asked at what period of the life of the *Scytonema* or *Sirosiphon* does it become invaded by the parasite? at what part of the thallus does it make an entry? It must be near the base, or at all events not very high up, for the hypha is found growing pretty nearly *pari passu* with the growth of a branch of the alga and in the same general direction. But why might not the hypha grow in the opposite direction? Might it not sometimes enter near the apex and grow backward? Might we not sometimes expect to find hyphæ sticking out from broken-up or distorted examples of these algæ, and thus revealing themselves (*without* the whole mass being boiled in potash) whilst *on their way* to other examples of quite the *same* alga? Or must the hypha appertaining to a particular plant have had its commencement from a spore which found its way to, and alighted *somewhere* externally upon, the particular *Scytonema* or *Sirosiphon*?

An experimental decision of the "gonidia-question," so far as it relates to these Scytonematous and Sirosiphonaceous forms, is surrounded by not a few practical difficulties. A "sowing" of spores upon the algæ (as Reiss did for *Nostoc*) in a natural condition could only be carried out by an observer residing in or close to the subalpine situations where these plants dwell, as they could not be cultivated elsewhere. In order to obtain the spores he would further have, most probably, a troublesome preliminary search, and, on the other hand, there would hardly be a

certainty of the plants selected for *inoculation* being themselves previously destitute of hyphæ or apothecia. Of course, small portions from various places in a tuft of any given *alga* could be previously well examined, which, though if, indeed, found to represent the alga "pure and simple," would not render it absolutely conclusive that some *other* portion of the tuft might not already have been invaded by the "parasite." However, having selected some plants for experiment they should be well inoculated with spores, and portions removed from time to time for examination and experiment. If found satisfactory it would be interesting to try spores from the *same* and from *different* species, in order to see the result, and whether the seeming fixity of the forms and the apparently extreme choiceness of the *parasites* be true or not, or ultimately whether the theory itself be true or not. Whether, for the time being, the truth of the new theory be previously assumed, or its untenability be presupposed, would matter very little, if only the suitable opportunity and ready field of operation were at command of the observer. It would seem as if in this way only can either presupposition be justified or negatived.

On the Form of Pollen-grains in relation to the Fertilization of Flowers. *By* ALFRED W. BENNETT, *F.L.S.*

Although a common form of pollen-grain not unfrequently runs through a whole group of plants, yet more often the form is found to be adapted to the particular requirements of the species in respect of its mode of fertilization, and varies even within a small circle of affinity. In those plants which are fertilized by the agency of insects, there are three general modes in which the form of the grain is adapted for the purpose. We have, first (and this is by far the most common form), an elliptical grain with three or more longitudinal furrows, as in *Ranunculus Ficaria*, *Aucuba japonica*, and *Bryonia dioica*; secondly, spherical or elliptical, and covered with spines, as in many Compositæ, Malvaceæ, and Cucurbitaceæ; and thirdly, where they are attached together by threads or a viscid excretion, as in the Fuchsia, Evening Primrose, and *Richardia æthiopica*. In those plants, on the contrary, which are fertilized by the agency of the wind, as most grasses, the Hazel, and *Populus balsamifera*, the pollen is almost perfectly spherical when dry, unfurnished with any furrows, and very light and powdery. The genus *Viola* furnishes two very markedly different forms of pollen-grain: in one, the section to which *V. canina* and *odorata* belong, they have the ordinary elliptical 3-furrowed form, and every point of the structure of the style and stigma is favourable to fertilization by bees; in the other, the section to which *V. tricolor* belongs, the grains are very much larger, and either hexagonal or pentagonal, and the style and stigma are adapted for fertilization by very minute insects, such as Thrips. In all species of the order Cruciferæ at present examined, the pollen has the most common form. *Pringlea antiscorbutica*, the "Kerguelen's Land Cabbage," has been shown by Dr. Hooker to be in all probability wind-fertilized, from the following considerations:—the absence of petals, the absence of honey-glands, the exserted style, the stigma being covered with long papillæ, and the apparent entire absence of winged insects in Kerguelen's Land. The form of the pollen supports the same view, being very minute and perfectly spherical, extremely different, therefore, from every other known plant of the order. In the cowslip and primrose there is a uniform difference in size between the pollen-grains from flowers belonging to the two dimorphic forms, that of the short-styled being always considerably larger than that of the long-styled form.

On the Embryogeny of certain Species of Tropæolum. *By* Professor DICKSON.

On an Abnormality in Chrysanthemum leucanthemum. *By* Professor DICKSON.

On Structural Peculiarities of the Ampelideæ. *By* Professor Lawson, *M.A.*

On a Monstrous State of Megacarpæa. *By* Dr. Moore.

On a Monstrous Flower of Sarracenia. *By* Dr. Moore.

On Grafted Roots of Mangold-Wurzel. By Dr. Moore.

On the Growth of the Stems of Tree Ferns. By Dr. Moore.

Mosses of the North-east of Ireland. By S. A. Stewart.

Turner in 1804 enumerated as Irish 230 species of mosses, Dr. Taylor in 1836 mentions about the same number, and Dr. David Moore in 1872 gives a list of 385 Irish species, to which the author of the present paper adds four others, making 389, or more than two thirds of the British mosses. Thus, relatively to the British flora, Ireland has quite as large a proportion of mosses as she has of flowering plants, proving that Irish muscology has not been neglected. No separate lists of the mosses occurring in the northern counties have been published; but after consulting the records of Dr. Taylor in the 'Flora Hibernica,' and the valuable list of Irish mosses by Dr. Moore, also some detached papers on the subject and his own unpublished notes, the author ascertains that the number of species occurring in the district amounts to 225, or more than one half of the Irish mosses. The district is defined to consist of the counties of Down and Antrim, with a small portion of county Derry bordering on Antrim. The list includes a number of rare mosses. The following have not been previously recorded as Irish:—*Fissidens incurvis*, Schw., var. *Lylei*, found only on a greensand rock on the Black Mountain, near Belfast; *Tayloria serrata*, in small quantity near the summit of Benbradagh Mountain, county Derry; *Mnium subglobosum*, in wet peat-bog on Cave Hill, near Belfast, and in a similar habitat on Carrickfergus commons; *Seligeria calcarea*, on Black Mountain, near Belfast, appearing like little black specks on small lumps of chalk in the grass. Mr. C. P. Hobkirk, of Huddersfield, has been kind enough to identify the specimens of the above-named mosses.

On the Potato-Disease. By James Torbitt.

The author believes that the potato cannot be propagated for ever from the "set," that it dies of old age in about thirty years after it is grown from a seed, that to eradicate the disease it must be grown from the seed, and it must be planted beyond the range of infection emitted by old infected varieties. The author believes that the range of infection does not extend beyond a few hundred yards.

On Specimens of Marine Algæ from Jersey.
By C. J. B. Williams, *M.D., F.R.S.*

These specimens were prepared by Miss E. Dyke Poore, who had found as many as 230 species on the shores of Jersey. This remarkable abundance and variety of seaweeds, as well as their luxuriant growth, Dr. Williams attributed partly to the position of the Channel Islands, receiving tides and currents from the great Atlantic as well as the channel; and partly to the remarkable clearness and purity of the sea-water as contrasted with that of the muddy shores of the southern and eastern coasts, due to the chalk, marl, and sand of their shores, whereas those of

Jersey consist chiefly of clean primitive rocks, which form little *débris* and no mud. Turbid water is unfavourable to growth, by intercepting the light as well as by its mechanical effects on delicate organisms.

The method by which Miss Dyke Poore prepares the specimens so as to preserve their colour and minute structure so perfectly is not novel, but may be referred to this principle—that as these delicate forms and organisms are developed and supported in a medium of nearly the same specific gravity as their own, so they must be kept disentangled and cleansed as much as possible in sea-water, and transferred to fresh water for the purpose of washing away the salt and of laying them out only immediately before the processes of drying and pressing. Thus prepared, and fixed by a slight brushing of skim-milk or weak solution of isinglass, they may be kept in a book, or sent by post between pasteboards without damage; but light and damp may still injure them.

Zoology.

[For Dr. Hooker's Address see page 102.]

On some Points in the Histology of Myriothela phrygia*. *By* Prof. Allman, *F.R.S.*

The endoderm of that portion of the body which lies at the distal side of the gonosome, and which carries the papilliform tentacles characteristic of the genus, is composed of numerous layers of large polyhedral cells with clear contents and a brilliant nucleus. Internally it forms thick conical processes which project into the body-cavity, while externally it is continued in an altered condition into the tentacles. At the free end of the internal processes there are abundantly developed among the large clear cells smaller spherical cells filled with opaque brown granules. These cells are easily detached and isolated, and may be then seen lying free in the body-cavity. Where the endoderm passes into the cavity of the tentacles, it loses its large clear-celled condition, and consists of small round cells loaded with opaque brown granules.

External to the endoderm and interposed between this and the ectoderm is the fibrillated layer. This is remarkably well developed. Its component fibrillæ run circularly round the body, and form a continuous fibrillated membrane so strong as to remain entire after the tissues on both sides of it have been broken down. No obvious membrane distinct from this and forming a separate "Stützlamelle" could be detected. It is continued as a thinner membrane into the tentacles, where it lies between the endoderm and ectoderm of these processes.

The ectoderm is mainly composed of two or three layers of small round cells filled with yellowish granules. Among these cells the thread-cells may be seen lying at various depths from the surface. The ectoderm retains this structure over the body and tentacles; but between the proper ectoderm and the fibrillated lamina of the body a peculiar tissue may be demonstrated. This consists of a layer of cells, from each of which there proceeds a fine process which can be distinctly traced into the fibrillated membrane. In this membrane the cell-processes lose themselves; and they could not be followed into direct continuation with the fibrillæ in the way in which Kleinenberg traced the prolongations of cells apparently having the same significance in the ectoderm of *Hydra*. These cells differ also from those described by Kleinenberg in *Hydra* in their being nowhere superficial. In a transverse section of the body in *Myriothela* the caudate cells form a distinct zone immediately external to the fibrillated lamina and between this and the proper ectoderm. They are strongly stained by magenta, while the fibrillated membrane takes up scarcely a trace of the colour. It is impossible not to see in this tissue elements referable to a very primitive type of the nervous system.

* [Received after the close of the Belfast Meeting. Printed with the authority of the Council.—G. G.]

But perhaps the most remarkable point of structure is to be found in a peculiar tissue which is developed between the endoderm and ectoderm of the tentacles. It occupies the summit of the tentacle, where it is interposed between the continuation of the fibrillated membrane of the body and the ectoderm, forming here a hemispherical cap over the endodermal cavity of the tentacle. It is composed of colourless, transparent, closely applied prisms, which extend at right angles to the walls of the cavity. It strongly suggests the rod-like tissue of the retina.

On Chlamydomyxa labyrinthuloidea (n. g. et sp.), *a new Sarcodic Freshwater Organism. By* William Archer.

This paper gives an account of a novel sarcodic organism from fresh water, presenting a very considerable resemblance to those two congeneric marine forms regarded as the type of a new family instituted by Cienkowski, and named by him Labyrinthulea. In Schultze's 'Archiv für mikr. Anatomie,' in a memoir entitled "Ueber den Bau und die Entwickelung der Labyrinthuleen" (see also Quart. Journ. Micr. Sci. vol. vii. p. 277), that author gives an account of the new organisms so named, found by him amongst algæ on piles in the harbour of Odessa. These, as stated by him, are characterized by being composed of three elements or constituents—the *central mass*, the *spindles*, and the *filamentary tracks* ("Fadenbahn," Cienk.). In the organism now brought forward we have all these elements—that is to say, the central sarcodic "body-mass," the "spindles," and the "filamentary tracks." In all the filamentary tracks are minute, extremely slender hyaline threads, emanating from the central mass, stretching far and wide into the surrounding water, and forming an irregularly connected, much ramified, arborescent framework, along which the spindle-shaped bodies travel slowly in great numbers, away from the central "headquarters." But the main distinction (apart, of course, from minor differences of colour and the like) between the "spindles" in Cienkowski's forms and the present is that in the latter they are not nucleated, whilst in the former they are. Another distinction is that in the present organism the aggregate body-mass presents a remarkable tendency to become repeatedly encysted or coated with a thick hyaline multilaminated covering, the densely arborescent body-mass being only now and again protruded through a torn-like opening in the covering; this covering gives the cellulose reaction on the application of iodine and sulphuric acid. Another important distinction lies in the fact that the body-mass possesses, immersed in its substance, numerous irregularly figured deep crimson-coloured pigment-granules, giving to the organism, viewed under moderate powers, a decidedly red colour. A further difference of importance in the present form is its "parasitic" habit, or, at least, the fact that in a younger state of existence it inhabits the cells of aquatic plants, such as *Sphagnum*, the immersed leaves of *Eriophorum*, sedges, &c., or (in Connemara) the tissues of *Eriocaulon*; from these hosts it protrudes by-and-by, becomes re-encysted, and at last removed. A minor distinction occurs in the fact that the spindles here are of a bluish hue, not, as in Cienkowski's forms, either orange-coloured or colourless.

This curious organism is manifestly one of which at present no record exists; its true nature is somewhat problematic, its "*facies*" is that of a "Labyrinthulean," but the non-nucleated spindles are seemingly a bar to its admission as yet to a place in that group; it does not resemble any of Häckel's Monera, it has no seeming immediate affinity to Rhizopoda, and, so far as we can see, must continue for the present an isolated problematic production which Mr. Archer would mean time suggest should remain in abeyance, standing under the designation *Chlamydomyxa labyrinthuloidea*. A lengthened description and illustration will appear elsewhere of this curious and puzzling organism.

Further Researches on Eozoon Canadense. *By* William B. Carpenter, *M.D., LL.D., F.R.S.*

The Foraminiferal character of the Serpentine Limestone of the Laurentian formation in Canada having been recently again called in question, the author has been

led to make a careful reexamination of the matter—with the result of satisfying every microscopist who has seen his preparations of the unmistakably *Nummuline* character of the "proper wall" of the chambers as discovered and described by Dr. Carpenter ten years ago.

On Atya spinipes, *and on an undescribed* Pontonia. *By* Professor Cunningham.

On English Nomenclature in Systematic Biology. By E. Ray Lankester, *M.A.*

On the Genealogical Import of the Internal Shell of Mollusca. By E. Ray Lankester, *M.A.*

On Spring Migratory Birds of the North of England. By T. Lister.

The observations made by the author at Barnsley, Yorkshire, during the years 1853–74 are embodied in the following list:—

	Average date of first notice.	Approximate date of departure.
Redstart (*Ruticilla phœnicura*)	April 15.	September 20.
Whin-Chat (*Saxicola rubetra*)	April 20.	September 22.
Wheatear (*S. œnanthe*)	March 28.	September 30.
Grasshopper Warbler (*Salicaria locustella*)	April 26.	September 5.
Sedge-Warbler (*S. phragmitis*)	April 22.	August 31.
Reed-Warbler (*S. strepera*)		
Nightingale (*Luscinia philomela*)	April 25.	July 27.
Blackcap (*Sylvia atricapilla*)	April 21.	October 10.
Garden Warbler (*S. hortensis*)	May 6.	September 10.
Whitethroat (*S. cinerea*)	April 24.	September 27.
Lesser Whitethroat (*S. sylviella*)	April 28.	September 15.
Wood-Wren (*Phyllopneuste sibilatrix*)	April 30.	September 18.
Willow-Wren (*P. trochilus*)	April 10.	September 26.
Chiffchaff (*P. rufa*)	March 29.	October 4.
Ray's Wagtail (*Motacilla Rayi*)	April 13.	September 14.
Tree-Pipit (*Anthus arboreus*)	April 15.	September 22.
Swallow (*Hirundo rustica*)	April 10.	October 15.
Martin (*H. urbica*)	April 13.	October 12.
Sand-Martin (*H. riparia*)	April 10.	September 20.
Swift (*Cypselus apus*)	May 22.	August 15.
Nightjar (*Caprimulgus europæus*)	May 21.	August 30.
Grey Flycatcher (*Muscicapa grisola*)	May 14.	September 2.
Pied Flycatcher (*M. atricapilla*)		
Cuckoo (*Cuculus canorus*)	April 14.	August 25.
Land-Rail (*Crex pratensis*)	April 22.	October 5.

Some rare migrants, the dates of which cannot be furnished, have occurred in Yorkshire and the north of England, as the Hoopoe, Wryneck, Bee-eater, Roller, Spotted Sandpiper, Spotted Crake, and Baillon's Crake.

On two new Species of Pentastoma. *By* Professor Macalister.

Notes on the Specimen of Selache maximus *lately caught at Innisboffin. By* Professor Macalister.

On the Distribution of the Species of Cassowaries.
By P. L. Sclater, *M.A., F.R.S., Secretary to the Zoological Society of London.*

After some general observations on the systematic position of *Casuarius* and of its allied form *Dromæus*, the author proceeded to remark on the great increase in our knowledge of the species of the former genus that had recently taken place. One species only (the *Casuarius galeatus*) had been until lately recognized, whereas at the present time there was evidence of the existence of at least seven or eight distinct species distributed over New Guinea and the adjoining islands.

The Zoological Society of London had received, on the 27th of May last, a living Cassowary which appeared to belong to a species hitherto unrecognized. This bird had been obtained at the southern extremity of New Guinea, in the early part of 1873, by Dr. Haines, the Medical Officer of H.M.S. 'Basilisk,' and brought to Sydney, where it remained until February of the present year in the Botanic Gardens. Thence it had been brought to England in the ship 'Parramatta,' under the care of Mr. Broughton.

The species, which the author was intending to describe before the Zoological Society as *Casuarius picticollis*, was closely allied to Bennett's Cassowary (*C. Bennetti*) and Westerman's Cassowary (*C. Westermani**), and belonged to the same section of the genus, distinguishable by the transverse ridge across the helmet and the want of caruncles on the neck.

The author then pointed out the principal characters distinguishing the seven species of Cassowary known to him, as shown in the subjoined Table, and made remarks on their distribution, which were illustrated by reference to a map of New Guinea and the adjoining islands:—

a. Casse lateraliter compressâ: appendiculâ cervicis duplici.
  1. *C. galeatus*, ex Ceram.
  2. *C. bicarunculatus*, ex inss. Aroensibus.
  3. *C. australis*, ex Australia.

b. Casse transversim compressâ: appendiculâ cervicis unicâ.
  4. *C. uniappendiculatus*, ex Papua.

c. Casse transversim compressâ: appendiculâ cervicis nullâ.
  5. *C. Westermanni*, ex Papua.
  6. *C. picticollis*, ex Papua merid.
  7. *C. Bennetti*, ex Nov. Britann.

Anatomy and Physiology.

[For Professor Redfern's Address see page 96.]

On the Development of the Elasmobranch Fishes. By F. M. Balfour, *B.A.*

The author described some of the more interesting features of the early stages in the development of Elasmobranch Fishes. The paper is published in full in the Quart. Journal of Micr. Science for October 1874.

On some Points in the Physiology of the Semicircular Canals of the Ear.
By Professor Crum Brown, *M.D., F.R.S.E.*

On the Development of the Powers of Thought in Vertebrate Animals in connexion with the Development of their Brain†. By James Byrne, *A.M., Dean of Clonfert, and ex-Fellow of Trinity College, Dublin.*

In this paper a minute analysis was applied to the constructive instinct of the beaver, and it was shown that that instinct involved thought, but that the thought

* *C. Kaupi*, Scl. (olim) nec Rosenb. See Proc. Zool. Soc. 1874, p. 248.

† Published *in extenso* in the 'Journal of Anatomy and Physiology,' November 1874.

was limited to the present act in which the animal was engaged, or, at most, took in very little beyond it, the native impulse or desire seeking each step in succession by itself, because the animal's power of thought could not take in the end of the series.

A typical case of intelligence in the dog was similarly analyzed; and it was shown that the dog had the power of thinking a particular act as a part of a series, combining with the idea of that act a thought of the series of acts, each with its effect, and all with their result. It was pointed out that this power of forming a plan to attain an end, which was possessed by the dog, differed from man's power of design in this respect, that man can not only think an act as part of a series leading to a result, but that he has the further power of believing, with more or less certainty, that each step in the series of acts will be followed by the consequence connected with it in thought. This implies inference from past experience, and inference is the process of imparting to the idea of a fact the degree of assurance which belongs to it as a case of a general principle.

Characteristic instances of intelligence in the baboon and the orang-outang were minutely analyzed; and it was shown that while these manifested an intelligence to which the dog could not attain, the superiority consisted in the power of combining in an assured sense of reality with the idea of an object some abstract coexistence or succession which had been gathered from similar objects as a uniformity of experience; that is, in the power of thinking a case of a general principle with the belief which belongs to it as such.

This step of mental development in the orang-outang compared with the dog is similar in its essential nature to the previous step, which may be observed in the dog compared with the lower vertebrate animal. Each is a new power of combining thoughts which otherwise would have required a long course of repetition in conjunction with each other before they could by association have grown together; and each combines those thoughts in a closer and more vivid union through the medium of a new element—namely, sense of progress towards an end in the one case, and belief in the maintenance of a uniformity in the other.

It was shown by a general survey of the highest kinds of intelligence manifested by the various classes and orders of vertebrate animals, coupled with a minute analysis of apparently contrary instances, that vertebrate animals may be divided in respect of their mental powers into three groups, of which the lowest can comprise in one act of thought only what can be perceived by sense all at the same time; the second can comprise in one act of thought a series of successions in time so as to think a single object of sense as part of such a series; and the third can comprise in one act of thought an entire class of coexistences or successions so as to combine with a particular fact the common element of coexistence or succession belonging to the class. To the first group belong the vertebrate animals below the Rodent order of Mammalia. In the second group the Rodents may claim a place (though their powers of purpose are small), along with the orders of Mammalia above them up to the Quadrumana. To the third group belong the monkeys, the Anthropoid apes, and man.

With these facts of the development of intelligence, the facts of the development of the brain are in striking correspondence. "For the cerebrum of the oviparous vertebrata corresponds only with the anterior lobe of the human cerebrum. It is among the Rodentia that we meet with the first distinct indication of a middle lobe; while the posterior lobe makes its first appearance in monkeys, and is distinctly present in the Anthropoid apes" (Carpenter's 'Mental Physiology,' p. 116). And the inference at once occurs, that the functions of the anterior lobe belong to the act of thinking single objects of sense, those of the middle lobe to the act of thinking such objects with a sense of a succession of them and as part of that succession, and those of the posterior lobe to the act of thinking a coexistence or succession of them as a case of a general principle.

In confirmation of this inference, the other features of brain-development were considered; and it was shown that the analogies of the nervous system seem to indicate that the increased development of the fibres of the brain serves to make the action of its different parts consentaneous, so as to give correspondence to the muscular action of the two sides of the body and strength and steadiness to

thought, this function being more needed as powers of thought are developed which are less closely connected with sense; and accordingly the great transverse commissure appears first, in any degree of development worthy of notice, in the Rodents along with the middle lobe. The increased size of the cortical layer and the number and depth of its convolutions probably give an increase in the amount of thought and in its analysis. And the cerebellum, connected as it is principally with the spinal cord, seems to be a store of force which, having been set in action by the contracted muscles through the posterior nerves, continues to maintain, through the anterior nerves, the stimulus to muscular action, so as to keep up the action of the muscles which have been set in action till it is altered or suspended by the action of other nervous centres. Thus no other development of the brain seems to have any tendency to give that extension to thought which was assigned to the three lobes. The convolutions and the fibres improve the action of the brain rather than enlarge the range of its objects; but the development of each additional organ of intelligence extends the range of the objects of thought. And it is as superadded developments that the three lobes appear, both in the vertebrate series of animals and in the development of the embryo of man.]

Lastly, it was shown that the course of development of cerebral function which had been inferred from facts was in accordance with the general analogies of development, as giving the powers which were needed in the struggle for life; for the primary function of the cerebrum being to direct the actions of the body by the thoughts of the mind to the attainment of desirable ends, the intelligence of which it is necessary that it should be the instrument is knowledge of the ends and knowledge of the means. And the development of that intelligence consists of three steps—the power of thinking objects as desirable or undesirable, the power of thinking actions as leading to ends, and the power of knowing objects to be desirable and actions to be efficacious. Accordingly the first lobe of the cerebrum should be developed to combine in thought qualities with things as their substance, the second lobe should be developed to think acts in time with a view to their end, and the third lobe should be developed to think a fact with the belief which belongs to it as a case of a general principle.

Along with the power of thinking each of these classes of objects would come, in a greater or less degree, in proportion to the other developments of the cerebrum —the power of thinking their relations and comparative attributes, and that of combining them with each other and with emotions, desires, and aversions.

And if it were objected to these inferences that considerable portions of the cerebrum may be removed without any apparent mutilation of the powers of thought, it might be observed that the acts of the mind become by association so connected with each other, that in each thought there are many associated elements, and that the corresponding seat of cerebral activity should be not in one but in many localities throughout the brain. Even if some of these were removed, the action of the others would still by association elicit and be elicited by the accustomed impressions of the sensorium and stimulation of the centres of muscular action.

On a new Form of Microscope for Physiological Purposes. *By* RICHARD CATON, *M.D.*

This paper consisted of a description of a microscope modified with a view to the easier examination of the tissues of warm-blooded animals. Hitherto the phenomena of circulation &c. could only be studied in the mesentery and omentum; this instrument is intended to render practicable the examination of other tissues, as, for example, the subcutaneous cellular tissue and the brain-membranes. The front half of the stage, as ordinarily constructed, is removed, so as to allow the body of the animal to be brought into close contact with the object-glass. A small glass trough, one third of an inch in diameter, containing salt-solution, is attached to the centre of the stage immediately under the objective. The piece of tissue to be examined is laid across the glass trough, and held in position by two pairs of small stage-forceps. As the object cannot be moved about on the stage so as to bring any part of it as required under the object-glass, a corresponding movement

is given to the body of the microscope by a simple mechanical arrangement. The stage-trough containing salt-solution is warmed by a very simple hot-water apparatus, the temperature being registered by a stage-thermometer in the usual manner.

Preliminary Notice of an Inquiry into the Morphology of the Brain and the Function of Hearing. By Professor Cleland, *Galway.*

In this paper it was demonstrated that the flocculus is a lateral projection from the third cerebral vesicle, and that the optic thalami are not developed in the first cerebral vesicle but in the constriction between it and the second. The author's hypothesis is, that the cerebral hemispheres are derived from the front of the first cerebral vesicle by a process of longitudinal fission, similar to that which he had formerly shown to take place in other cephalic structures (Phil. Trans. 1862), that the primary optic vesicles have a closer connexion with the second than with the first cerebral vesicle, and that the olfactory bulbs, optic vesicles, and flocculi are serially homologous; and he judges that the flocculi are connected with the sense of hearing.

Observations, with Graphic Illustrations, on a pair of Symmetrical Bones present with the Fossil Remains of Iguanodon. *By* W. Waterhouse Hawkins, *F.L.S.*

Note on the Development of the Columella Auris in the Amphibia. By Professor T. H. Huxley, *F.R.S.*

In his paper "On the Structure and Development of the Skull of the Common Frog" (Phil. Trans. 1871), Mr. Parker states that, in the fourth stage of the tadpole *, "the hyoid arch has made its second great morphological change; it has coalesced with the mandibular pier in front and with the auditory capsule above (plate v. figs. 1–4, and plate vi. fig. 8, *s.h.m.*, *i.h.m.*). The upper part, or suprahyomandibular (*s.h.m.*), is attached to the auditory sac much lower down and more outward than the top of the arch in front. . . . . This upper distinct part is small; it answers to only the upper part of the Teleostean hyomandibular; there is a broad sub-bifid upper head answering to the two ichthyic condyles, then a narrow neck, and then behind and below an 'opercular process' (*op.p.*). Below this the two arches are fused together; but the hyoid part is demonstrated, just above the commencement of the lower third, by the lunate fossa for the 'styloid condyle' (plate v. figs. 2 & 4, *st.h.*)." (pp. 154, 155.)

In the sixth stage "the 'suprahyomandibular' (fig. 3, *s.hm.*) has become a free plate of cartilage of a trifoliate form" (p. 164).

In the seventh stage "the 'suprahyomandibular,' losing all relation to the hyoid arch, becomes now part of the middle ear. . . . The *essential* element of the middle ear, the stapes (*st.*), was seen in the fourth stage; the condyles and opercular process of the hyomandibular are now being prepared to form an osseo-cartilaginous chain from the 'membrana tympani' to the stapes. Under these conditions a new nomenclature will be required; and this will be made to depend upon the *stapedial* relationship of the chain, notwithstanding its different morphological origin.

"I shall now call the lobes of this trifoliate plate of cartilage as follows—namely, the antero-superior 'suprastapedial,' the postero-superior 'medio-stapedial,' and the freed opercular process 'extrastapedial' (*s.st.*, *m.st.*, *e.st.*).

"The stapes (*st.*) sends no *stalk* forwards to meet the new elements, but they grow towards it; this will be seen in the next stage." (pp. 169, 170.)

As the question of the origin of the *columella auris* in the *Vertebrata* is one of considerable morphological importance, I have devoted a good deal of time during the past summer to the investigation of the development of this structure in the frog; and it is perhaps some evidence of the difficulty of the inquiry, that my

* That is, when there is a branchial aperture only on the left side, and the hind limbs are rudimentary or very small.

conclusions do not accord with those enunciated by Mr. Parker in the very excellent and laborious memoir which I have cited.

I find, in the first place, that there is no coalescence of the mandibular with the hyoidean arch, the latter merely becoming articulated with the former.

Secondly, Mr. Parker's "suprahyomandibular" is simply an outgrowth of the mandibular arch from that elbow or angle which it makes when the pedicle by which it is attached to the trabecula passes into the downward and forward inclined suspensorial portion of the arch. This outgrowth attaches itself to the periotic capsule, and, coalescing with it, becomes the *otic process*, or "superior crus of the suspensorium," of the adult frog.

The hyoid arch, seen in the fourth stage, elongates, and its proximal end attaches itself to the periotic capsule in front of the fenestra ovalis, and close to the pedicle of the suspensorium, which position it retains throughout life.

The *columella auris* arises as an outgrowth of a cartilaginous nodule, which appears at the anterior and superior part of the fenestra ovalis, in front of and above the stapes, but in immediate contact with it. It is to be found in frogs and toads which have just lost their tails, in which the gape does not extend further back than the posterior margin of the eye, and which have no tympanic cavity, as a short and slender rod, which projects but very slightly beyond the level of the stapes, its free end being continued into fibrous tissue, which runs towards the suspensorium, beneath the portio dura, and represents the suspensorio-stapedial ligament of the *Urodela*.

This rod elongates, and its anterior or free end is carried outwards as the tympano-eustachian passage is developed. At the same time the free end becomes elongated at right angles to the direction of the rod, and gives rise to the "extra-stapedial" portion, which is imbedded in the membrana tympani. Ossification takes place around the periphery of the middle of the rod; thus the medio-stapedial is produced. The inner portion becomes the rounded or pestle-shaped supra-stapedial, but retains its primitive place and connexions; whence we find it in the adult articulated in a fossa in that part of the periotic capsule which forms the front boundary of the fenestra ovalis, but in close contact with the stapes.

The *columella auris* of the frog, therefore, is certainly not formed by the metamorphosis of any part of either the mandibular or the hyoidean arches, such as they exist in the fourth stage of larval development.

It may be said further that the *columella* undoubtedly *appears* to be developed from the side walls of the auditory capsule in the same way as the stapes; and some appearances have led me to suspect that it is originally in continuity with the stapes, but I am not quite sure that such is the case.

Are we to conclude, therefore, that the columella is a product of the periotic capsule, such as the stapes has been assumed to be?

Here, I think, there is considerable ground for hesitation. It appears to me that the stapes is not so much "cut out" of the cartilaginous periotic capsule as the result of the chondrification of a portion of that capsule which remains unchondrified longer than the rest.

Moreover the *Urodela* all possess a band of ligamentous fibres which extends from the stapes to that part of the suspensorium with which the hyoid is connected and to the hyoid itself. It is conceivable, and certainly not improbable, that this stapedio-suspensorial ligament represents the dorsal extremity of the hyoidean arch. But the *columella auris* in its early condition in the frog so nearly resembles the stapedio-suspensorial ligament partially chondrified, that it is hard to suppose that one is not the homologue of the other; in which case the columella, and even the stapes itself, may, after all, represent the metamorphosed dorsal end of the hyoidean arch or the hyomandibular of a fish. And it must be admitted that the relation of the portio dura nerve to the hyomandibular of a ray speaks strongly in favour of this view.

On the Development of the Eye of the Cephalopoda. *By* E. Ray Lankester, *M.A.*

On the Tongue of the Great Anteater. By Professor MACALISTER, *M.D.*

On some Anomalous Forms of the Human Periorbital Bones. By Professor MACALISTER, *M.D.*

On the Influence of Food, and the Methods of supplying it to Plants and Animals. By Professor REDFERN, *M.D.*

On the Effects of Ozone on the Animal Economy. By Professor REDFERN, *M.D.*

On the Decomposition of Eggs.* By WILLIAM THOMSON, *F.C.S.*

Researches on this subject were commenced by the late Dr. F. Crace-Calvert and myself about the beginning of October 1870, and continued during the following 18 months.

We made many series of experiments, among which I may mention first some good whole eggs were set aside on a shelf and examined from time to time to observe the action of ordinary atmospheric air. The shells of some set aside in the same way were pierced by a fine needle. Some were exposed in this way to dry and others to moist atmospheres, some to constant and others to constantly varying temperatures. The effects were observed of placing some close to putrid meat, and others, for the sake of comparison, in good air; the air in both cases was kept heated to between 80° and 90° F. for many weeks. Experiments were made by exposing them in different gases, moist and dry; some with their shells whole, and some pierced by a fine needle; and, lastly, the effects of placing on the shell the dried germs of different agents of decomposition, and also of placing the eggs in water and other solutions containing different animalculæ &c. in active life, were observed.

Besides these experiments, however, we examined rotten eggs obtained from different vendors at different times of the year, and the results from all may be summed up generally as follows:—

That eggs with their shells perfect are attacked and decomposed by one, two, or all of three different agents of decomposition. The first we termed "The Putrid Cell," the second "The Vibrio" and the third "The Fungus Decompositions."

"*The Putrid Cell*" we have found to spring entirely from the yolk; and it seems to be the morbid growth of the bioplasm, which, had the egg been hatched, would have gone to form the blood, bone, and tissues of the chicken.

These cells gradually enlarge to several hundred times their original size, and at the same time other cells develop in their interior. Ultimately the parent cell bursts, and those in the interior take independent existence, and undergo the same process of development. These cells convert oxygen into carbonic dioxide; and in one case, where an egg, which we ultimately found to have been decomposed solely by this agent, was enclosed in an atmosphere of oxygen contained in a bottle of 18-ounces capacity for 118 days, only 0·2 per cent. of oxygen remained, 95·06 per cent. of carbonic dioxide and 4·74 per cent. of nitrogen, together with a much smaller amount of other gases, were present. But oxygen is not necessary to the growth of this peculiar ferment. In two eggs laid on the same day, which were carefully and thoroughly varnished with shellac, and set aside on the same shelf, exposed to the air for 1 year and 9 days, and then broken and examined, one was found to be quite good, and free from smell or any germ of decomposition; whilst the other, on being struck with the point of a knife, burst open, and scattered part of its contents in all directions. It was completely decomposed, and emitted a very bad smell. The yolk was completely mixed up with the white; and on micro-

* *Vide* 'Chemical News,' vol. xxx. p. 159.

scopical examination no other germ could be observed except multitudes of these "putrid cells." If this ferment be mixed with water and whole eggs immersed therein, these cells will penetrate the shells of the eggs and develop in their contents. Germs of different animalculæ are generally found on the outside of the shells of eggs; and when thus placed in water these animalculæ develop and swim about in the liquid.

In the above experiment it was remarkable to observe that four different kinds of animalculæ developed in the water in which the eggs were placed. One of these we termed the "screw;" it had exactly the appearance of from one and a half to two and a half turns of a corkscrew; its body remained rigid, and propelled itself along by turning quickly round, on the same principle that a corkscrew penetrates a cork. The next two we termed respectively the unifilamented and bifilamented fluke. Under the microscope they appeared like flukes, but their real appearance resembled that of an egg. Some possessed one and some two filaments about three times the length of themselves; and by aid of these, which they switch into a quick peristaltic motion in front of them, they were enabled to swim quickly along. The fourth kind was the ordinary vibrio, which, together with the putrid cell, were the only agents of decomposition which we ever found to penetrate the shell of a whole egg and develop in its interior. In several other experiments eggs were left in fluids containing immense numbers of these animalculæ, but in no case did we ever find that they had been able to pass through the shell of a whole egg.

The Vibrio-decomposition.—The class of animalculæ to which we give the name of "Vibrios" has been described in former papers by the late Dr. Crace-Calvert before the Association. They resemble a worm in appearance. Their bodies remain straight and rigid, and in most fluids which contain them some swim about or move to and fro, and many are generally observed to be motionless and apparently quite dead. The germs and dried bodies of these animalculæ are wafted about in the atmosphere, and seem to be natural to it. They are never found originally in the contents of an egg, but are often found to be the cause of decomposition in rotten eggs.

If the outside of the shells of eggs be kept dry from the time they are laid, this decomposition cannot proceed, inasmuch as the dry bodies of the animalcules cannot make their way through the shell. If, however, the shell be kept wet for some time, the egg is certain to become putrid by the agency of the vibrio. A little of the albumenous contents dialyzes out, and thus gives the necessary food for the development and growth of the vibrios or their germs, which are everywhere floating about; and it is only when they attain to a certain degree of vitality in the moisture on the outside that they can make their way into the interior. These vibrios absorb oxygen and give out carbonic dioxide. Eggs which are kept wet in oxygen very soon become very putrid through this vibrio decomposition; but in coal-gas and carbonic dioxide the growth of the animalcule is prevented, and the egg generally remains good. Vibrios were found in many eggs which had their shells pierced and were kept dry; but in some, where the shells were pierced, vibrios did not appear; the albumen seemed to dry over the hole and close it, so that in two cases, when the shells of the eggs were pierced, the contents dried up (no germ of decomposition having entered) and appeared good and free from smell. The white could then easily be cut out, and moulded between the fingers like putty.

The Fungus-decomposition.—This agent of decomposition is very different to the former two; it is composed of fine filaments, which grow in immense numbers, and with much rapidity, in albuminous solutions. The fungus found generally is the *Penicilium glaucum*; its spores are always found floating about in the atmosphere. If dry eggs are placed in a constant current of air they will seldom, if ever, be attacked by this agent of decomposition; the air-current seems to prevent them from taking root on the shell; but if, on the other hand, they be protected from air-currents, this fungus generally makes its appearance and penetrates the shell. The filaments then begin to spread in all directions. In some cases all sides of the shell are bound firmly together by these filaments, stretching from all sides; so that the egg could not be opened by the usual modes of operation, and the shell had to be completely torn to pieces, or the binding filaments cut with a knife. In all cases

the filaments entwine into each other in the albuminous contents, forming themselves into a semitransparent half-coagulated looking mass, and in many cases into a thick coating of about the consistency of cheese. The greatest facility is afforded to this fungus to pass through the shell when it is damp, as moisture enables the fungus to take root; and it is remarkable that, when penetration of the shell has thus taken place, the calcareous matter of the shell is loosened, and when the outside is rubbed it feels rough to the fingers. Its growth is entirely prevented by carbonic-acid gas and coal-gas. Hydrogen and nitrogen do not permit it to grow, although they do not seem to be actually poisonous to it. It absorbs oxygen and liberates carbonic dioxide, so that it flourishes most luxuriantly in the former gas. Eggs decomposed by the *Penicilium*-filaments emit no smell, as the round spores do not develop under liquids or at the parts to which the filaments penetrate; but the spores soon begin to grow from the surface of any of the filaments exposed to the air, and the egg then begins to exhale a mouldy smell.

The filaments decompose the albumen, and liberate, among other products, a large proportion of nitrogen, which we have ascertained beyond doubt by enclosing eggs, in specially fitted bottles, in atmospheres of pure oxygen. As an example, on analysis of the resulting gas in one experiment, we found:—

	per cent.
Oxygen	48·06
Nitrogen &c.	10·15
Carbonic dioxide	41·79
	100·00

Lastly, we found that eggs placed in water containing the spores of this ferment mixed up with it were not attacked by them.

Anthropology.

[For Sir William Wilde's Address see page 116.]

On Modern Ethnological Migrations in the British Isles. *By* Dr. Beddoe, *F.R.S.*

Various causes have led in our own times to an extensive amount of migration of our people, executed peaceably, gradually, and by individuals or by families. In Britain a constant stream of population sets towards the capital, to a great extent from distant counties, and including a considerable proportion of the upper and middle classes. Elsewhere in Britain, and in Europe generally, the migration, as a rule, takes place from poor to rich districts, from ill-employed to busy, from hilly to plain, from rural to oppidan, from healthy to unhealthy districts. The effect of mere proximity is often overborne by other circumstances. In Scotland there are two currents—one towards England and the other towards Glasgow. It is the more Celtic of our people that form the masses which are attracted to our large towns. Thus Glasgow receives a rapid influx of Irishmen and Highlanders. In Edinburgh the case is different, although there the Celtic element is strong in the lower classes. In Liverpool this element is strengthened by constant Irish, Welsh, and Scotch immigration. Irish blood abounds in most of the colliery districts of the north of England. London has not a large proportion of Irishmen. In Ireland itself Dublin was formerly, but Belfast is now, the great focus of attraction; and even many of the smaller towns have attracted to themselves the neighbouring Celtic population.

On the Peoples between India and China. *By* Sir George Campbell, *K.C.S.I.*

Note on the River-Names and Populations of Hibernia, and their Relation to the Old World and America. By Hyde Clarke.

Having pointed out that a Celtic explanation for rivers in these islands is not allsufficient, he called attention to the circumstance that the same names as in Ireland and Britain were found in Ancient India and elsewhere. Thus, *Tamaros* and *Tamarus, Tava* and *Tava, Tina* and *Tyna, Senus* (Shannon) and *Sonus, Tamesa* and *Adamas, Tamion* and *Temala, Ausoba* (Moy) and *Sobanus, Ravius* and *Arabius, Tobios* and *Attabas.* Beyond this he referred to the conformity of these British and Indian names with those of ancient civilized America, as *Tamaros* and *Tamar, Senus* and *Sinu, Ausoba* and *Sibu, Tamion* and *Tamoin,* in compliance with the general fact of the almost identity of Indian and Peruvian names. This was referable, not to the Phœnicians, but to that much earlier period of civilization of the Sumir and Accad in Babylonia, and to be called Sumirian, when the world was of one official speech, and great monumental cities were raised by people speaking allied languages in Southern Europe, Asia Minor, Babylonia, India, Indo-China, Peru, and Mexico. To this epoch were to be referred the gold ornaments of Ireland and the fire-worship of Baaltin, and perhaps the round towers in their origin. With regard to the very varied population of Ireland, beyond Celtic, English, and the Basque, or so-called Iberian types, Mr. Clarke considered it should be compared for higher and lower Caucasian types. He recommended a close investigation of the names of places.

Note on the Phœnician Inscription of Brazil. By Hyde Clarke.

The author doubted its authenticity on internal evidence, as King Hiram would not send an expedition from Eziongeber on the Red Sea to America. The Atlantic and Pacific Oceans, Australia, North and South America were known in the earliest stages of learning in Babylonia, and were distinctly taught in the doctrine of the Four Worlds by the School of Pergamos, and which lingered till the discoveries of Columbus. The Canaanites were of the same speech as those allied to Sumir and Accad of Babylonia, who had spread civilization throughout the world, and had occupied and founded Peru and Mexico. Although the knowledge only existed in a misunderstood tradition among the Greeks and Romans, it was accessible to the Phœnicians; and Hiram would have despatched his expeditions from Tyre, or from Spain, and not from Eziongeber.

The Agaw Race in Caucasia, Africa, and South America. By Hyde Clarke.

The author gave a copious account of this family of languages as one of those which denoted a general migration throughout the world. He first examined the Abkhass of Caucasia, which he identified with the Achaia Vetus. Of this branch he gave a detailed account, suggesting that they were the Havilah of Genesis, the Akaiusha of the Egyptians, and that they gave name to the people known in Greece as Achivi, and in the west as Aquitani. Passing to the Nile region, he compared the language and grammar of the Agaw and of the Falasha or Black Jews. In India, he referred to the Kajunah and Gadaba as possibly allied. Tracing the migration across the Pacific, he showed how widely spread the language is, under the names of Guarani and Omagua, in Brazil and Paraguay, driven forward by the Aymara and Inca empires of the after-Sumirian migration.

Mr. Clarke suggested that some of the earlier river-names of the Old World and America were Agaw, referring to Iberus, Siberis, Tiberis, Liparis, Baris, Para, Parana, Parahyba, Paraguay. The Agaw race had never constituted cities and kingdoms; such belonged to the later Sumirian epoch. In South America, although covering such a vast extent, the people were in the same political condition as in Abyssinia or Caucasia.

A Note on Circassian and Etruscan. By Hyde Clarke.

The author found that the Circassian was closely related to the Otomi, Tarahumara, Cora, and Huasteca of Mexico. This Circassian migration must have preceded that of the Sumirians across the Pacific, of the Aymaras and Incas in Peru, of the Maya in Yucatan, and the Aztek in Mexico. At an historical period the Otomis are found turning back and attacking the Mexican kingdoms. The relationship of Otomi to the languages is distant, but yet showing the same affinities as Circassian does to the Sumirian group in the Old World, and notably to Etruscan. The Etruscan he regarded as distinctly Sumirian, on the evidence of its words, its grammatical forms, its numerals, mythology, and topographical names. The particle *tl* was found in Circassian and in Etruscan languages.

A Preliminary Note on the Classification of the Akka and Pygmy Languages of Africa. By Hyde Clarke.

This was an inquiry undertaken at the request of the Italian Geographical Society with regard to the dwarfs seen by Schweinfurth, Miani, and Professor Owen, and now at Naples. The language is not related to the languages of the Bushmen, Mincopies, Fuegians, Shoshons, and other short races. It conformed to that of the Obongo, the discovery of which by Du Chaillu in West Africa had been discredited, but was thus confirmed. Its other African relations were with the Moko, Rungo, Gonga, Ankaras, and Wuni; for besides the Pygmies of the Nile, the ancients had referred to Pygmies in India. Mr. Clarke had made a special examination and found traces of Akka and Obongo where they would naturally be distributed among the Garos, the Nagas, and the Gadaba, Savara, &c. The African types were distinctly traceable in languages related to the Carib in South America, as Baniwa, Ueanambeu, Tocantins, &c. It is evident, however, that the shorter races and languages are mixed up with those of more powerful Dahomans and Caribs, which will have to be divided. The Akka words for woman are of the most ancient type, and preserved by us and other civilized races to this day. The whole formation is prehistoric. Thus tooth, tusk, horn, and bone afford the names for elephant and bull, and leg for fowl.

With regard to the neighbours of the Akka, the Niam-Niam, Mr. Clarke stated that the course of the migration was that of the boomerang (of Col. Lane Fox) in a line of legends of cannibals, filed teeth and tailed men from Africa, through the Australasian archipelago to Australia.

On the Distribution of the Races of Men inhabiting the Jummoo and Kashmir Territories. By Frederic Drew, *F.G.S., F.R.G.S.*

From their position at the very north-west corner of India, at that part of its mountain barrier which has been the seat probably of some of the earliest settlements of the races which now form the chief part of the population of India, these territories both present ethnological problems of the deepest interest, and afford a rare store of facts available for their solution. In this paper the author desires to contribute some facts from his own observation without attempting much in the way of inference from them.

In the enumeration of the races the principle is adopted of taking them as they exist now in communities having common characteristics (what may be called nations, even though they may not in most cases possess political unity), and not the principle of tracing out each *caste* in the various localities. For instance, among the Dogrās, Pahāris, and Kashmīrīs, there are many of the Brahman caste, and to the two former several other castes are common. The tracing of each caste through the various nations in the hope of throwing light on their origin would be an interesting task, but the author has not been able to collect materials for it. He has taken the broad distinctions of communities as they actually exist, and mapped them village by village.

The distribution, as well as the characteristics, of the different races is much

affected by the physical features of the country. Geographically, the first division is to be drawn between those on the south-west side and those on the north-west side of the snowy range which makes the watershed between the Chināb and Jhelam rivers on the one hand and the Upper Indus on the other.

In the basins of the Chināb and Jhelam (in the latter of which is included the country of Kashmir) are found the four races—*Dogrās, Pahārīs, Kashmīrīs,* and *Chibhālīs.* All these are of Aryan origin, and, though differing among each other, have all a countenance of distinct Aryan type.

The *Dogrās* occupy certain portions of the outer ranges of the Himalayas, from the foot of the hills at a level of 1000 feet above the sea to heights of 3000 and perhaps 4000 feet. They are a race of fair height, but slim; active, but not powerful. They have well-formed and rather delicate features. Their complexion is of a brown colour, like that of the almond-husk, but rather darker. They are divided up into castes, in great part corresponding with those found among the other Hindūs.

The *Pahārīs** occupy the higher mountains next beyond; their dwellings are at heights from 3000 or 4000 feet up to 9000 or 10,000 feet; they are, moreover, in some cases, situated between mountains of much greater altitude. The men of this race are stronger, of a more powerful frame, than the Dogrās, but still they are active. They have good features, thoroughly Aryan, a good brow, and a decidedly hooked nose. Both in appearance and disposition they are very different from the Dogrās; their habitat among the hills where snow falls has been the cause of many differences both in their customs and their nature.

In the *Kashmīrīs,* whose race is the next to be mentioned, the differences which existed between the Dogrās and the Pahārīs (at all events as far as physique is concerned) are carried further. The Kashmīrīs have a very powerful frame, broad shoulders, muscular backs, and strong limbs. In feature they present probably the best form of the Aryan type of countenance. They commonly have a high and wide forehead, a square brow, and a well-shaped nose, which in the older people becomes curved.

The Kashmīrīs occupy their own enclosed valley of Kashmīr, and have spread from it somewhat and formed isolated colonies, both in the neighbouring hills and at a greater distance.

Inquiry has at different times been instituted about the Kashmīrī language, and a good deal of information has been given, both as to its vocabulary and its grammar, notably by Mr. Bowring, Sir George Campbell, and Dr. Elmslie. The author is not in a position to add to this; but he wishes to point out what has hitherto not been observed, that the Kashmīrī is one of a *group* of languages or dialects. The Pahārīs before described speak not one but several dialects, and these are closely connected with Kashmīrī. One of these may be reckoned as about halfway between Dogrī and Kashmīrī (Dogrī itself being connected with Panjābī and Hindī), while other of these dialects approach still more closely to Kashmīrī. Some special characteristics of that language, such as the occurrence of *ts* and *z*, where in Hindī dialects *ch* and *j* would occur, are found in all the Pahārī languages.

We thus find that, in language as well as in physique, a passage more or less gradual can be traced from the Dogrās, through the Pahārīs, to the Kashmīrīs.

To understand our next division, we must first consider the religion of those races that have been enumerated.

Of the Dogrās, by far the larger portion are Hindūs. The Pahārīs are almost entirely Hindūs. The Kashmīrīs, originally Hindūs, have been so far Muhammadanized that perhaps only one tenth remain of their old faith, and nine tenths are followers of Muhammad.

Now the *Chibhālīs,* our next race, are all Muhammadans. They consist of people of two, or possibly of three, of the former divisions who have become Muhammadan and have acquired, partly from that reason, and partly from geographical separation, such characteristics as may now entitle them to be called a race. The Chibhālīs extend from the outermost hills between the Chināb and Jhelam rivers northwards over mountains of 8000 and 10,000 feet in height. Those in the

* The word *Pahārī* means in the Hindī dialects "mountaineer." The Dogrās, however, commonly restrict the use of it to denote the particular race in question, and I follow the practice for want of another name.

southern part of this area are distinctly Dogrās who have been converted to Muhammadanism. Further north they seem to have been originally more like the Pahāris. Yet further north, those called in this paper Chibhālis have possibly a greater ethnological connexion with the Kashmīris.

We have now reached the high mountains. These are so lofty and inaccessible that the inhabitants are restricted to the valleys which ramify among them.

Here to the north and north-east of the snowy range we find one race of Aryan origin, the *Dārds.* These Dārds, as has been shown by an examination of their languages (into which Dr. Leitner, if not the first, has been by far the most complete and successful inquirer), and as can be inferred from their physiognomy, are of Aryan origin. Into these territories they came from the north-west, gradually migrating; their furthest point in a southerly direction is four days' march short of the capital of Kashmīr; in reaching this they spread over the watershed into the basin of one of the tributaries of the Jhelam; to the south-east also spreading they reached to within the boundary of Ladākh. Their villages are at levels from 4000 feet high (in the Indus valley near to Gilgit) up to 10,000 feet.

The Dārds are tall men, broad-shouldered, and well-proportioned; they are bold and active mountaineers. They have a good cast of countenance, though they seldom reach to the degree of being handsome. Their hair is generally black, but sometimes brown; in this they show a difference from all the other races we have dealt with, among whom black hair is, the author believes, universal. Their eyes are either brown or hazel; he does not think that he has seen any blue.

For religion, the Dārds of these territories had formerly an idolatry of which we know little, and which may or may not have resembled that of the Hindūs. They have now become for the most part Muhammadan; but a few villages, from their contact with the Ladākhis (a contact probably that occurred before the introduction of Muhammadanism), have adopted the Buddhist faith.

We now leave the Aryan and come to three subdivisions of the Tibetan race.

People of this race extend all along the Indus valley and into the various tributary valleys from Chinese Tibet down to below Skārdū. At one spot only within the territories we are treating of are they found on the south side of the snowy range. These Tibetans must have come from the south-east, where the main mass of their race now live. They must have come, in search of a livelihood, across a long stretch of uninhabitable country. As they reached parts of the Indus valley fit for grazing and for dwelling in, they stayed with their flocks, herds, and tents. Again, they found their way further down the valley to where cultivation was practicable, and there they became agricultural.

Of our three subdivisions all speak dialects of the same Tibetan tongue, and all have something of the Tibetan or Chinese cast of features. There are, first, the *Chāmpās,* those on the south-east; these are still nomadic tent-dwellers; they have sheep and goats and yāks; they occupy high-level valleys at altitudes of 14,000 and 15,000 feet, changing their camp according as the season of the year gives most pasture in one place or another.

Next are the *Ladākhis,* settled Tibetans, dwellers in villages at heights of from 13,000 down to 10,000 feet.

The people of these two subdivisions, the Chāmpās and the Ladākhis, are Buddhists.

The third subdivision is the *Balti* race. The Baltis were formerly the same as the Ladākhis, but now they so far differ from them that they have become Muhammadan, and have acquired peculiarities that arise from the customs which that religion brings with it.

Thus with these various races has been filled up the space, all or nearly all the habitable ground, of the territories named.

Of the bearing of the facts of distribution on the general question of the mode of peopling of these countries, little more can at present be said than that it seems quite clear that the Tibetans came into the area we are dealing with from the south-east, and that the Dārds came into it from the north-west and north. Of the four races enumerated on the south side of the snowy range, the course of migration is not plain. But it is something to know the connexion that exists between each of them—to know that, in spite of the differences, one can pass, not very gra-

dually, perhaps, but still without any great break, from the Kashmīrīs to the Dogrās, who themselves are related not distantly to the people of the plains of India.

The races spoken of are those which make the great majority of the population of the various districts mapped. In some parts these are mixed up with the small numbers of the remnants of the pre-Aryan inhabitants. Among the Dogrās and Pahārīs, the tribes or castes called (in ascending order of social position) Dums, Meghs, and Dhiyars are of this older blood. Among the Kashmīrīs, a low caste, called "Bātal," seem from their position and occupations to have a similar origin. The Dārds also, and the Tibetans as well, contain certain classes whose partial social separation from the others may denote that they have sprung from such an old source; but if so, they have become much more nearly allied, by mixing of blood, to the Dārds and Tibetans respectively, whom they live with, than is the case with the low castes among the Dogrās.

Maps illustrating the subject of this paper have been prepared, one of which, enlarged, was shown to the Section. The author desired it to be understood that it was chiefly the information on geographical distribution of the races as laid down on this map that was original; the enumeration of most of the races had been made by previous authors; especially was acknowledgment due to Sir G. Campbell's paper "On the Ethnology of India" in the Journal of the Asiatic Society of Bengal.

The Degeneracy of Man. *By the* Rev. Joseph Edkins, *Peking, China.*

This paper was divided into four sections. In the first the question was stated. Races occupying a continent are more civilized than those which inhabit islands at a great distance from continents. The intellect of nations sinks in power under geographical conditions of an unfavourable nature.

The influences which tend to improve the human race and aid its progress were enumerated, viz. genial climate, intercourse with civilized races, religious training, the discovery of metals, &c.

The unfavourable influences were then detailed, viz. loss of knowledge, restricted acquaintance with nature, &c.

Asia was probably the birthplace of the whole human family; and the question is, therefore, whether the inhabitants of Polynesia, America, and Africa are not all degraded Asiatics, and the Europeans improved Asiatics.

To help in solving this question linguistic, moral, social, and religious facts must be collected and compared.

This paper simply drew together a few facts from China, Polynesia, and America.

Though the question of degeneracy chiefly affects savages, the paper stated that there were some things in regard to China which deserved consideration.

The second section treated of China. China, though isolated by the Tartarian desert and the mountains of Tibet, showed vestiges of communication with the west, both recently and in extreme antiquity.

The old signs of connexion with Western Asia were the cycle of sixty, made by the combinations of ten and twelve, a dual philosophy, a hebdomadal division of time, a doctrine of five elements, which require us to assume ancient connexions with Babylon. To these should be added the arts of weaving, writing, astronomical calculations, divination, agriculture, which seem to show that Chinese primeval civilization was certainly not self-originated.

Subsequently the degeneracy of China was prevented by the opening up of communication with the west and by other causes, such as the establishment of education through the country.

The extension of the Chinese empire, so as to embrace Turkestan and Cochin China, about 1900 years ago, and the introduction of Buddhism, which taught the Chinese Hindoo science, and with it Greek science, powerfully tended to prevent the decline of the Chinese intellect.

It was then pointed out that China has been a civilizing mother to all the neighbouring nations. Corea was civilized, and Japan through Corea. The coins, paper money, politics, and arts of Japan are all copies of Chinese types.

The fruitfulness of Chinese civilization among all her neighbours should lead us to expect that its influence has reached much further, viz. among the islands of the Pacific and on the American continent.

The third section treated of Polynesia. Hindoo ideas of religion and cosmogony penetrated beyond Java into some of the Polynesian islands. Chinese navigators used to make voyages to Ceylon and still more distant points in the Indian Ocean. A thousand years before Christ there was extensive commerce in the Indian Ocean carried on by the various inhabitants of western nations.

The extension of the Malay and Polynesian languages from the Sandwich Islands to Madagascar should be looked at in the light of this fact. The military enterprises, mercantile activity, and spread of the arts in the Indian and Pacific Oceans of that time are lost to history; but the sculptured remains in Easter Island, the striking indications of Semitic influence, and the existence anciently of a higher knowledge of navigation than now indicate degeneracy in the Polynesians.

The knowledge of their own traditions is rapidly disappearing, as shown in the experience of missionaries resident in the islands. The Rev. W. Gill, of Mangaia, by great effort obtained amounts of old cosmological and mythological beliefs, and he is now the sole depository of them, the old people that supplied them having died and left no disciples to transmit the knowledge of them. This is proof that the knowledge of these islanders tends to become more and more circumscribed as the ages roll on.

The Polynesians all count, or could once count, to a hundred, and did so when their ancestors spoke a common language. This is proof of former high civilization; for decimal notation, though consistent with savage life when isolation has caused degeneracy, always bespeaks civilization in the time of a nation's early history.

If the Polynesians, as these facts show, were formerly civilized, it was because of their connexion with Asia. That connexion is proved by identity of customs and beliefs with those of Asia; for example, the practice of circumcision in Tonga with other Semitic customs, the belief in paradises and a pantheon, which remind the inquirer of India. Their language has words arranged in a Semitic order, agreeing also with the order of words in the Siamese and Annamite languages. The Polynesians avoid the mention of the proper name of persons held in honour. Their honorific phraseology is in this and other respects very like the Chinese. Among the Chinese linguistic peculiarities found in the languages of Polynesia may be mentioned the extensive use of numeratives between numbers and nouns, as in the Ponapean. This is not Aryan, nor Semitic, nor Ural Altaic; but is both Chinese and Polynesian, and exists extensively in the Caroline Islands. It is a fact of the greatest importance in the linguistic part of the argument.

The logic may here be reversed. The connexion with Asia being proved, degeneracy is proved too. Among the races of Asia the northern were in one respect inferior to the Polynesians, as shown by the want of identity in names of number.

The fourth section was on America. The geometrically constructed mounds in North America prove deterioration.

In America the facts are mixed; in Polynesia they are of one kind. In America the facts point to North Asia and to South Asia; in Polynesia the facts point to Southern Asia only.

In America the art of writing, belief in paradises and future punishment, the use of idols in temples, &c. indicate connexion with Southern Asia; so also traditions of the deluge and certain linguistic laws.

The best hypothesis for the origin of the Mexican and Peruvian civilization is an immigration within the tropics and across the Pacific. The small islands of the Pacific represent much larger tracts which have at some unknown epoch become submerged. The ancient civilization of Polynesia points out the path by which the higher products of the intellect in the form of civilized ideas and customs could most conveniently find their way to America.

The Mexican idea of the deluge is of South-Asiatic origin. The Mexican pictures, idols, and temples resemble those of Southern Asia rather than those of China.

The doctrine of future punishments, as believed by North-American tribes, is more like the ideas of Southern Asia.

The Northern Asiatic languages have strongly marked peculiarities, which are

found in some of the most widely-spread Indian languages. Professor Rochrig, in his tract on the Dacota language, points out the intensitive in adjectives as a remarkable instance of resemblance in that Indian tongue to the Mongol.

Dacota: *sa-pa*, black; *sap-sa-pa*, very black.
Mongol: *hara*, black; *hab-hara*, very black.

While the Dacota resembles in many respects a Tartar language, it places the adjective after the substantive, in which respect it departs from the Northern Asiatic type, and follows the Polynesian, the Siamese, and the Semitic.

It is this mixture of linguistic principles which forms the key to solve the problem of the origin of the North-American languages. The Dacota language is now accessible to ethnological inquiry in the exceptionally good dictionary and grammar of the Rev. S. R. Riggs, both included in the Smithsonian series. A predominant Tartar structure is the basis of the language; a limited Polynesian element, with certain features of home growth, form the remainder of the type. The facts of the Dacota are fatal to the theory of some American philologists, who, on *à priori* and unscientific grounds, refuse to recognize the possibility of a common origin to the Ural, Altaic, and Dacota languages.

The author proceeded to say that a remarkable instance of mixture occurs in the case of the Algonquins, in recent times the most widely spread of the North-American races. Their language is fundamentally of the northern Asiatic type, as may be seen in Howse's grammar of the Cree; and they have the adjective in its right place, but they are more Indian and less Asiatic than the Dacota. In regard to religion, however, they have mixed elements. The offerings to ancestors are Northern Asiatic and Chinese. Their view of the future state is so much of the Southern Asiatic type, that it embraces transmigration, which was unknown to China and Tartary before the spread of Buddhism.

The Patagonian religion, as recently described by M. Glardon, is strikingly like that of Siberian tribes, and he grounds upon their beliefs an eloquent defence of the doctrine of the unity of the human race.

The paper concluded with the statement that whether the Mexicans be compared with the Southern Asiatics or the existing Indian tribes with the Mongols and Turks, the process alike gives proof of degeneracy.

Longevity at Five score eleven Years.
By Sir G. Duncan Gibb, *Bart., M.D., LL.D.*

The author had brought forward nine examples at the previous meeting of the Association of persons who had overstepped the century by several years; and now his tenth instance of a female still living at Tring, in Hertfordshire, who had attained her hundred and eleventh birthday in April last, was given. He first gave some tables, carefully compiled by Mr. Henry Rance, of Cambridge, containing 84 instances of persons whose age extended from 107 to 175; 40 of these were under 130, and 44 above that age; and he considered that three fourths of the total number might be taken as correct. The proof of that was the instance he brought forward of Mrs. Elizabeth Leatherlund, now alive in her 111th year, the baptism of whom was given from the register of the parish of Dover in Kent. This was further confirmed by the drowning of her son and his family, and other persons, to the number of thirty-seven, at Hadlow in Kent in 1853, in the hop country, by a catastrophe mentioned and described in the papers of the time. Her son was then 59, and if now alive would have been 80, his birth occurring when his mother was 29 or 30. Other corroborative circumstances were stated, clearly establishing the great age of the old dame, who was of gipsy descent. The author then described her condition, the result of a careful personal examination at Tring in October 1873. She walked with the aid of a stick, was short in stature, bent with age, complexion brownish, countenance a series of thick folds, and she had several sound teeth. She chatted away continually in a clear distinct voice, and was in possession of all her faculties, though somewhat impaired. She is a little deaf, takes snuff, her skin was as soft as velvet, and her hair quite grey. She was thin,

and the muscles of her neck stood out in bold relief. All her internal organs were in perfect health, lungs, heart, &c., and her pulse was as regular and soft as in a girl of 18. In fact the changes of old age, as met with in persons from 70 to 80, had not taken place in any of the tissues of the body, being thus similar to the nine other cases examined by the author. She was, of course, feeble; but, taking all things together, that did not prevent her reaching to her present exceptionally great age. Her age, the author said, taught us two lessons—one was the absence of senile changes for the most part in centenarians, which was the chief reason of their attaining to such a great age; the other the occurrence now and then of instances wherein even six score years is reached, if not more. To ignore all past cases of extreme ultra-centenarian longevity because we cannot get at their proofs at the present day, he considered unphilosophical and unscientific; for there existed as conscientious and painstaking inquirers after truth then as exist now, whose statements and recorded facts must not be wholly ignored, as every honest investigator well knows.

Notes on the rude Stone Monuments of the Khasi Hill Tribes. By Major H. H. Godwin-Austen, *F.R.G.S. &c.*

In continuation of previous communications on these monuments, the author gave some further details derived from another visit to the Khasi Hills. He described the monoliths standing in the village of Nougshai, near Shillong. Attention was also directed to the cairns in the Khasi Hills. These cairns are to be seen only on the north side of the Khasi plateau. Similar cairns were, however, observed by the author near North Munipur.

On the Character and Distribution of rudely worked Flints in the Counties of Antrim and Down. By W. Gray, *M.R.I.A.*

Origin and Characteristics of the People in the Counties of Down and Antrim; an Ethnological Sketch. By the Rev. Canon Hume, *D.C.L., LL.D.*

Omitting all but a passing notice of the early inhabitants of the district, the writer started from the beginning of the seventeenth century. The resident Irish were then one assimilated, if not a homogeneous people; and the English and Scotch immigrants formed two other great constituents. The former were traced from the shore of the channel at Carrickfergus, past Lisburn, and along by the Lagan and Bann and the shores of Lough Neagh; while the latter passed inland, from the projecting points of Galloway and Cantyre, by Donaghadee and Carrickfergus. These were known respectively, until within the last few years, as the English and Scotch districts, the native Irish occupying the mountains and bogs.

In illustration of the general subject, the writer referred in detail to numerous topics, showing that the characteristics are preserved to this hour with more or less distinctness. Thus the names of townlands are often translated, and their English equivalents used; but in a far greater number of instances a family surname is affixed to Bally, Dun, Rath, Fort, or Lisna. And the surnames themselves are curious, those of English, Irish, and Scotch origin occupying their respective localities, though some, like Moore, Smith, Thomson, Hamilton, Johnson, and Patterson, are widely diffused. In other instances, especially in the Irish districts, particular names are confined within narrow local limits, like the names of the Highland clans. In their case also epithets become surnames, especially those indicative of complexion, so that new surnames, such as Roe and Bawn, arise like Roy and Dhu in Scotland. Surnames are also translated, so that many persons have two distinct names, an Irish one and an English one, as M'Gurnaghan, Gordon; Hamish, James; M'Elshender, Alexander; M'Fetrich, Fitzpatrick. The evidence from manners and customs is very marked. There are the three types of houses and furniture, and even the food is different. The Englishman only is a gardener, regularly plants trees, or cultivates the apple; he occasionally drinks

cider and mead, while the Scotchman rejoices in brose, porridge, and oatcake, and the Irishman is confined to the use of the potato and some cheap condiment.

So lately as 1820 Irish was spoken occasionally in the mountainous districts of both counties, and broad Scotch near the coast and in a direct line inland; while in the English district Shakspeare was read without the help of a glossary, and the expressions in 'L'Allegro' and 'Il Penseroso' were those of daily life. Now much of this has passed away, and there is a well-defined provincial dialect, but with very marked local differences. There is a large amount of traditional ballad poetry, and many of the pieces which were published by Percy and Scott are well known to hundreds who never saw them in print. But the most permanent difference is found in the creeds of the people, for time does not appear to effect any appreciable change. In large and in small districts, not only here but in all Ireland, the rule is for one of the three religious communities to amount to more than 50 per cent. of the gross population; the exception is for the three to exist in approximately equal number. The Irish as a whole are Roman Catholics, the Scotch are Presbyterians, and the English Protestant Episcopalians. In the county of Down one creed preponderates in 81 per cent. of the places which were separately enumerated in 1861; in the province of Ulster the percentage is 78, and in all Ireland 86. Though this variety of population is sometimes attended with inconvenience, as in the case of popular riots, it is on the whole beneficial, by the sustained rivalship, not of individuals merely, but of large associations of men. And the writer pointed with confidence to the state of the district in corroboration of his sentiments.

On the Anthropology of Prehistoric Peru.

By T. J. HUTCHINSON, *F.R.G.S., late H.B.M. Consul for Callao.*

This memoir was illustrated by photographs, diagrams, and sketches of many ruins of prehistoric Peru. With these were illustrations of several items of Mr. Hutchinson's collection of Peruvian antiquities, now being exhibited at the Bethnal Green Museum in London. The paper commenced by recording how little is known up to the present of the glorious days of Peru, long before the time of the Incas; and the author conveyed his agreement with Mr. Baldwin as to the original South-Americans (notably those of Peru) being the oldest people on that continent. It proceeded to show how little dependence was to be placed on the romantic gasconading of the Spanish writers, with regard to the Incas, of whose fabulous origin and mythological genealogy no account was traced by them to a period further back than about seven centuries ago, or close to the time when William the Conqueror came to England. It likewise discussed the writings of various authors of whose works translations have been recently published by the Hakluyt Society, showing them to be full of anomalies and contradictions, in the vain attempt to make the Incas be considered the earliest civilized race of Peru. The grandeur in extent of the ancient burial-mounds was a wonderful thing. It was shown by the diagrams and illustrations. The colossal work of those done by human hands (and some of them measuring from 20 to 24 millions of cubic feet) proved what a superior race these early Peruvians must have been. The difference in *morale*, as in physique, of modern Peruvians and Chinese was commented upon to suggest that there could not have been (though supposed by very high authority) a homogeneity of origin. The paper further made a comparison of the burial-mounds explored by Messrs. Squier and Davis in the valleys of the Ohio and Mississippi, with those examined by the author in Peru. This showed the greater magnitude of the works in the latter country as regarded their size, although in mathematical construction both presented a similarity. A curious feature in the Peruvian mounds, as well as ruins of fortresses, consists in the fact that their terraces, bastions, squares, and other architectural features have an almost invariable measurement in multiples of twelve. The prehistoric ruins of Peru, described by Professor Raimondy in his recent work on the mineral riches of the department of Ancachs, were mentioned as highly interesting. Extraordinary things are the tombs cut out in the solid rock. But more wonderful still is the fact that these are of a stony formation, entirely different to the geology of the neighbourhood in which they are found, thus evidencing that these immense boulders, which are of

diorite, though invariably observed amongst sandstone strata, have been brought over the mountains and through the valleys of these apparently impassable Andes. The *modus operandi* of such transport is as yet an insoluble problem. One of the rock graves is described as fashioned in the shape of an egg (cut crossways), the upper part serving as a lid to cover the body when deposited within. The author concludes that, until a better system shall be adopted of examining ruins of burial-grounds, mounds, and fortresses than has hitherto prevailed, the most we can learn of prehistoric Peru will be little better than guesswork, dreaming, and speculation. The paper touched on the hyperbolical stories about Peruvian gold (rich though the country is in minerals), on the ancient navigation by *halsas*, and the wonderful works in art and manufacture of the early Peruvians:—"One of these primary tribes of people who, leaving no chronicle or history behind them but their works, have gradually disappeared from the face of the earth by some of those mysterious and inscrutable laws which Divine Providence dispenses for the rise and fall of the races of mankind." The author added that in the 'Guide to Belfast' compiled by members of the Belfast Naturalists' Field-Club for the use of members of the British Association, the following statement was made at page 194, under the head of "Sepulchral Monuments:"—"The popular idea is that all or nearly all the old forts were constructed by the Danes; but this is quite erroneous. The greater number of our ancient national monuments were erected hundreds of years before the landing of the Danes in Ireland." Just such a popular and erroneous idea as this existed in Peru with reference to the great works there being accredited to the Incas, whereas they were daily finding out that they were erected, like the Irish forts and mounds, hundreds if not thousands of years before there was an Inca in the land. He added that the process of inhumation used in prehistoric times in Ireland seemed to have been the same as in Peru.

A Glimpse of Prehistoric Times in the North of Ireland. *By* William James Knowles.

In many parts of the north of Ireland, especially along the sea-coast, quantities of flint flakes are found, collected together or lying scattered about, supposed to be the remains of flint-implement manufactories. Recently there have been found by the author at Portstewart, co. Derry, mixed up with such flakes, between 500 and 600 manufactured articles, such as scrapers, arrowheads, &c., together with fragments of broken pottery, numerous bones and teeth of horse, ox, dog, &c., and shells mostly of the same species as are now found along the sea-shore in that neighbourhood. The objects are found in pits excavated by the wind among sand-hills about a mile from Portstewart, and near the mouth of the River Bann, and have fallen to the bottom of those pits out of blackened layers seen on the sides. These blackened layers represent the ancient surface at the time the place was occupied by the prehistoric races, and are now covered over with sand from about 10 to 30 feet in thickness. The wind removes the sand as the sides of the pits crumble down, leaving the flakes, manufactured articles, teeth, and bones in the bottom. Scrapers amount to about 60 per cent. of the manufactured articles, arrowheads only 2 per cent.; and the great preponderance of scrapers and paucity of arrowheads was accounted for on the grounds that scrapers were easier of manufacture than arrowheads, and flakes suitable for the manufacture of the one were more abundant than those that would do for the other. Besides, scrapers would likely be employed in the preparation of skins for clothing; and that being a home operation many of them would be found, while arrowheads would be used at a distance, and therefore would not be so likely to be found near the place of manufacture. Several scrapers with concave scraping-edges were found, and are supposed to have been used in stripping bark off young branches for the purpose of curing skins, or for touching up portions of the skin after being gone over by the scraper by laying it over the finger. A number of hammer-stones of quartzite, two flat circular stones with holes in the centre, one whole but very poor stone celt, and a portion of a broken one were found; but it is rather remarkable that no trace of any thing resembling a flint axe was found in a place where flakes, cores, and manu-

factured flint implements are so abundant. The flint used appears to be rolled flints gathered on the shore; but if the prehistoric races of the north of Ireland were the flint-implement manufacturers for the whole of Ireland, as the author believes was the case, he considers that the supply of rolled and drift flints would be inadequate, and that we may look for evidence of mining having been carried on to obtain flint.

A circular stone with a flat edge, that could have been used for grinding grain, and several pieces of the top of a quern were found, from which the author concludes that the ancient people cultivated grain of some kind. There were no shell mounds found, like the "Kitchen middens," nor were there any fish-bones found, which was considered strange owing to the sea and a good fish river like the Bann being so near. Some of the bones were cut previous to breaking them to extract the marrow; and two bones were found manufactured into articles of use, one of which might have served as a whistle, and the other resembles a tool used by thatchers, called a "spurtle." From the fact of finding the spurtle, and there being several heaps of large stones among the sand, it was concluded that the prehistoric races resided permanently here and in thatched houses. No trace of ornament of any kind was found, but from finding several rubbed ochreous stones it was believed they painted the skin. The pottery was of two kinds, but that most abundant was coarse and similar in shape and ornamentation to sepulchral urns. One human bone was found; but the author stated that he was unable to decide whether they burned their dead before burial or whether they were cannibals. Traces of fire were common. He was of opinion, from their so patiently cutting the bone previous to breaking it to get the marrow, that they were not a ravenous people, and that food was abundant. He hoped, in conclusion, that further search would give us a clearer insight into the manners and customs of this ancient people.

The Methods of a Complete Anthropology. By the Rev. T. M'Cann, *D.D.*

Anthropology is defined to be the study of all the phenomena of the individual man. Man is a being who not only digests and assimilates, but also knows and feels. The former phenomena are considered in the Department of Anatomy and Physiology. The results of the faculties called mental alone are left for consideration in the Anthropological Department: these are the most important to man as such. This Department is only partially anthropological, while it confines its attention to the manifestations of mind in life and social customs. At present subjective observation and experiment (psychology) are excluded. Practically this is best, though theoretically it is wrong and unscientific. But it is not possible wholly to exclude them; in point of fact psychological phenomena are very largely introduced. The author then referred to the introduction of such subjects into the President's Address for this year; and in order that such questions should be thoroughly discussed, he proposed that papers on psychology alone should be read on one of the days appointed for sectional meetings, or to form a separate department for this subject, or else to originate a Society where men of opposite schools could meet and debate these disputed points as has never been done previously.

On M'Lennan's Theory of "Primitive Marriage." By Joseph John Murphy.

The author accepted Mr. M'Lennan's theory that in the earliest societies marriage in one sense was unknown, and that marriage (and consequently paternal authority) began with the practice of bride-stealing; but he dissented from Mr. M'Lennan's theory that the impulse to bride-stealing arose from the scarcity of women from the practice of female infanticide. There seems to be no sufficient evidence of this; and such a practice would tend to the extinction of the tribe practising it. The writer attributed the impulse to bride-stealing partly to the desire of each man to have a wife of his own (which in the earliest times could be only as the result of capture), partly to the instinctive impulse to mix the race. So soon as any tribe adopted bride-stealing generally, and as a consequence marriage and paternal

authority, the social cohesion produced by paternal authority would give that tribe an ascendency among its neighbours, and cause its customs to spread.

On "An Age of Colossi," with Examples, by Photographs and Drawings, of the various Colossi extant in Britain and Ireland. By J. S. Phené, *F.S.A., F.R.G.S.*

This was the continuation of a subject commenced by the author at Bradford. Some instances of similar customs between the Egyptians, early people of America, and Chinese (the latter being, in his opinion, the most modern) were referred to as showing a similarity of treatment and worship of the Nile and the Mississippi rivers by the vast similitudes found along the margins of each, indicating that the ancient constructors of these similar designs on both rivers had a common origin; hence that it was probable that America was peopled by Western-Asian emigration prior to the central parts of Europe or even of Central Asia, as the facility for a coast-line route would be much greater than an overland one to migratory people.

Subsequently a new feature presented itself in Egypt, of which he saw no evidence in America, the absence of which was well accounted for. In Egypt the River Nile became identified as the great beneficent serpent from the actual support of the Egyptian nation, through the river casting its great annual slough of mud, as the serpent casts its skin, giving a really tangible meaning to the adoption by the Egyptians of the casting of the serpent's skin as an emblem not only of revivification but of immortality, the actual permanence of the nation depending upon it.

In China, which he considered peopled subsequently to America, the same feature was found in a new phase. Instead of vast rivers being bordered with the great Colossi found in Egypt and America, artificial winding ways or courses, of sinuous and symmetrical arrangement, leading to tomb-temples, as in Egypt, were found, bordered with huge representations of animals as various and as mysterious as similitudes on the Mississippi rivers; and these courses or ways were, as far as he had at present been able to learn, called serpents by the Chinese—a fact by no means improbable in a country where the serpent or dragon is a religious emblem even to the present time. From these similar customs he concluded people of the same stock had at some period introduced the same customs, modified by time and locality, and that the periods of such introduction were of a very remote date. The evidence he had obtained as to the Chinese custom was very kindly given him by Mr. William Simpson, who had travelled extensively in Asia and America.

After giving these facts as to an *age* of Colossi, he again brought forward, amongst some of the Colossi of Europe, those of the British Isles, natural as well as artificial, showing in several cases that where huge natural similitudes of the human form or countenance were apparent, there vast artificial figures (some in Britain being larger than any other representations in the world) were to be found: the giant in Sussex 240 feet high, that in Dorsetshire 180 feet—in the vicinity of the first there being a great sphinx-like head on an isolated rock, which was a reputed Celtic deity, and vast human and other animal semblances on Dartmoor in the direction of the second. The great countenances in the white rocks near the Giants' Causeway appeared to have suggested similar simulation, as Pennant mentioned such a figure in the Isle of Arran just opposite, and a great lithic representation of the human form still exists in Sligo. The Colossi of Easter Island and of Elephanta, Ellora, and Bamian were then referred to. In the case of the Dorsetshire giant, he considered it probable that Cæsar had seen this as well as the figure at Wilmington—the one being, as he had before pointed out, near the place of his landing, the other on his way to Lidford, in the country of the West Britons, where, according to tradition, he and his army had been hospitably entertained; and he considered Cæsar's statement that the people had many such vast images thus sufficiently attested.

In consequence of the observations of Dr. Beddoe as to the interest attaching to the question, and the importance of ascertaining if any evidences of cremation could be found, he had been, he thought, successful in obtaining such evidences, though he gave reasons why, if there had not been such evidences nor any trace of them

in any particular figure, it should not affect the argument. The evidences he found were direct and indirect. On the breast of the giant in Sussex, at about a foot below the surface, he found a large number of small particles of burnt clay. On subsequently opening a tumulus on the Clyde he found precisely similar pieces of burnt earth; and on carefully reading again the account given by Strabo, he found the area was filled with hay and straw, in other words with vegetation hastily gathered and dried; and as the sedgy margins of streams near this great figure would afford such material most readily, and if (as it no doubt was) this was hastily collected and torn up, portions of the clay-soil would adhere to the roots, and such portions on being burnt would exactly resemble the burnt particles he had found. The indirect evidence was, that for obvious reasons he expected to find the largest amount of cremative matter at the feet of the figure, but on going to excavate it was found that an extensive square area had been removed to a depth of two or three feet; and he considered this could only have been done in consequence of the soil so removed being found to be particularly rich, and for that reason worth removal.

On "Natural Mythology," and some of the Incentives to its Adoption in Britain and Ireland. By J. S. Phené, *F.S.A., F.R.G.S.*

In this paper the author carefully abstained from any subject which might approach to natural theology, but confined himself wholly to instances of a mythological impersonation of remarkable natural objects, giving as an instance of his argument "the image which fell down from Jupiter."

A very large photograph of the Sphinx of Egypt was exhibited, for the purpose of showing the weathering of the stone, the characteristics of which led the author to think that the original and natural condition of the rock before being sculptured into its present form was that of a human similitude, and that this very fact had suggested the artistic labour displayed upon it. The diagrams showed a number of curious appearances of rocks in various parts of the world, some almost as like the human countenance in their purely natural condition as the Sphinx is at present. He thought that the localities of such objects had been sought as places of veneration, and no doubt for the celebration of religious and even sacrificial rites, and around them, as on Dartmoor, which abounded in such appearances, were tumuli and barrows of the dead. In such barrows were often found objects now preserved in museums; but these he considered, though generally looked on as the most important relics of the past, were not nearly so important as the positions of the barrows themselves with their surroundings. In looking at matters in this way he found in a number of instances, where the result of death in strife was not in question, that the sites were of peculiar and most interesting selection, as the place sacred to former worship by the deceased, his natural Gods (the sun, river, and rock-idols), &c. were all studied in the selection of the place where he reposed. Hence survivors and visitants to such tombs would soon identify (under the changes from weather and various natural effects produced by mist and varieties of light) these semblances with departed persons; and this once the case, every such similitude would be identified as the place of abode of some mythological spirit, power, or divinity, to which henceforth the place would be held as dedicated. That such matters were noticed by the ancients was clear from Ptolemy's description of the Capo del Orso, in the Mediterranean. All would be struck with the peculiar mythological personage Proteus as perhaps the strangest of the classic deities; but those who have witnessed the wonders of mirage in the Grecian archipelago and the Straits of Messina would comprehend how easily the superstitious and alarmed mind would see a Proteus or a Cyclops. Dartmoor and other similar places had the most surprising changes in appearance; and the same feeling would see in them deities of mist, mountain, and flood that were so popular in the mythological legends of different lands.

The Origin of the Moral Idea. By C. Staniland Wake.

Among even the lowest savages actions such as murder, adultery, and theft are looked upon as crimes, although they are not thought to be "immoral," as this term

is understood by us, the idea of immorality being wholly absent from the minds of such peoples. This is proved by the fact that it is only under particular conditions that those actions are disapproved of. The belief entertained by the person who suffers that theft and cognate actions are "wrong," is due to the idea of *personal right*, arising from the activity of the instinct of self-preservation. Interference with the "property" thus acquired would be resented as being wrong, and by association the idea of right in connexion with such property would instinctively be formulated, and would ultimately be transferred to others possessing similar property. It is owing to the fear of retribution that actions originally viewed as indifferent come to be treated as immoral. All primitive peoples recognize the "rights of the dead," the neglect of which they believe will bring on them the wrath of the denizens of the spirit-world. This belief gives rise to the idea that it is a *duty* to do what the spirits are supposed to require; and if by any means they are thought to disapprove of murder, adultery, and theft, these actions will come to be viewed as immoral. But as the moral attributes ascribed to the Gods are merely the reflex of the minds of their worshippers, the moral advance must first have been made by man; and probably this would be by the influence of some priest or chief, superior to his fellows, who sought to ameliorate their social condition. The negative virtues would be developed the soonest, but the active virtues of benevolence would ultimately be recognized. These are founded on the social affections, which can be traced back to the maternal instinct, if not still further to the sexual instinct which accompanies that of self-preservation with animals even of the lowest grade. The union of these instincts forms the true basis of morality. The reference to the instinct of self-preservation is requisite to supply the notion of "right," which is wanting to Mr. Darwin's theory of morals, as well as to the phase of utilitarianism of which Mr. Herbert Spencer is the exponent.

On Irish Crannogs and their Contents. By W. F. Wakeman.

The word "crannog," derived from the Irish word *crann*, a tree, means a wooden edifice. The Irish crannog was simply an island, altogether or partly artificial, circular or oval in form, the margin strongly staked with piles of timber, and the whole enclosed by rows of palisading. Within the enclosure were usually one or more log-houses. The boats used by the crannog builders were generally of great length, very narrow and shallow, and formed out of a single oak tree. The author believes that in not a few instances the islands may be referred to the Neolithic age, and in many cases to the bronze period. Nevertheless some of the crannogs were occupied up to recent times, and were frequently used by the makers of potteen, or illicit whisky.

On a Leaf-wearing Tribe on the Western Coast of India. By M. J. Walhouse.

The author described the Koragors from observations made when posted at Mangalore. These Koragors are a remnant of an aboriginal slave-caste, now numbering only a few hundreds. One of their distinctive peculiarities is that the women wear aprons or screens of woven twigs and green leaves. Formerly both sexes wore these aprons for clothing; but the custom is now confined to the women, and is useless, since it is worn over the clothes. It furnishes, however, a curious instance of how what was once a badge of degradation may survive as a cherished observance; for it is now considered that it would be unlucky to leave off these aprons. In spite, however, of this belief, the custom appears to be dying out.

GEOGRAPHY.

Address by Major Wilson, *R.E., F.R.S., F.R.G.S., Director of the Topographical Department, Horse Guards, War Office, President of the Section.*

The President of the Royal Geographical Society has so recently delivered his Anniversary Address, that if I were to attempt to trace the progress of geographical discovery during the period that has elapsed since the Meeting of the British Association at Bradford in September last, I could scarcely avoid repeating much that has already been said in far abler terms than I have it within my power to command. Still there are, at the present moment, certain subjects of such very general interest, and of so much importance, that they cannot well be passed over in any address to the Geographical Section of the British Association.

It has, I believe, been usual in the addresses to this Section to select some special subject for remark; and I will therefore, if you will allow me, before alluding to the geographical achievements of the year, draw your attention to the influence which the physical features of the earth's crust have on the course of military operations, to the consequent importance of the study of Physical Geography to all those who have to plan or take part in a campaign, and to the contributions to geographical science that are due, directly or indirectly, to war and the necessity of preparing for war. I do this the more readily from a feeling that sufficient importance is not attached to the study of geography as a branch of military science, and that of recent years officers in our foreign possessions and colonies have not received that encouragement which they might have expected to engage in geographical research, as well as from a hope that new life may be given to that spirit of enterprise and love of adventure in strange lands and amongst strange people which have so long distinguished the officers of both services.

To show how varied are the conditions under which war has to be carried on, and how much its successful issue may depend on a previous careful study of the physical character of the country in which it is waged, it is only necessary to remind you of the recent operations on the Gold Coast, brought to a successful issue in an unhealthy climate and in the heart of a dense tropical forest, where an impenetrable undergrowth, pestilential swamps, and deep rivers obstructed the march of the troops; of the Abyssinian Expedition landing on the heated shores of the Red Sea, and thence, after climbing to the lofty highlands of Abyssinia, working its way over stupendous ravines to the all but inaccessible rock crowned by the fortress of Magdala; of the march of the Russian columns across the steppes and deserts of Central Asia to the Khivan oasis—one month wearily plodding through deep snow, the next sinking down in the burning sand, and saved from the most terrible of disasters by the timely discovery of a well; and, lastly, of the great struggle nearer home, the last echoes of which have hardly yet passed away, when the wave of German conquest, rolling over the Vosges and the Moselle, swept over the fairest provinces of France.

The influence of the earth's crust on war may be regarded as twofold: first, that which it exerts on the general conduct of a campaign; and second, that which it exerts on the disposition and movement of troops on the field of battle. Military Geography treats of the one, Military Topography of the other; and it is well to keep this broad distinction in view, for, as with Strategy and Tactics, they stand in such close relation to each other that it is not always easy to say where Geography ends and Topography begins. Of special importance in the first case are great inequalities or obstacles that confine or obstruct the movement of large bodies of troops, and those features which retard or accelerate their march, whether they be mountain-ranges, ravines, or defiles with inaccessible sides, deep crevasses (such as those washed out in some steppe-countries by winter rains), extensive plains, dense forests, rich cultivation (such as that of the valley of the Po, which confines all movements to the roads), enclosed country like that of England and Ireland, great marshes (such as that of the Beresina and Pripet), or running or standing water that cannot be crossed without a bridge or boats. Of no less importance are those features which do not allow of the employment of large masses of troops or of special arms, such

as Cavalry and Artillery, as well as those circumstances that render the subsistence of large armies difficult or impossible. In the second case all inequalities of the ground, however slight, the nature of the soil and the effect which rain has upon it, the extent and character of the vegetation and cultivation, and all buildings, whether isolated or collected into towns and villages, are of more or less importance.

The climate of the theatre of war must always have an important influence on military operations, and should be the subject of careful study. Our own experience in the Crimea shows how much suffering may be caused by want of forethought in this respect. General Verevkin's remarkable march of more than a thousand miles, from Orenburg to Khiva, with the thermometer ranging from $-24°$ to $100°$, without the loss of a man, shows what may be accomplished with due preparation. Nor should the geological structure of a country be overlooked in its influence on the varied forms which the earth's crust assumes, on the presence or otherwise of water, on the supply of metal for repairing roads, and (if we may trust somewhat similar appearances on the Gold Coast, at Hong Kong, and in the Seychelles) on the healthiness or unhealthiness of the climate.

In any campaign undertaken by England, the sea must always play an important part as the great base of operations and main line of communication with the mother country. Special consideration must be given to the facilities which the coast-line of the theatre of war offers for effecting a landing; to the anchorages, shoals, roads, inlets, harbours, and depth of water along the coast; to the influence of the winds, tides, and currents on the entrance to harbours; to the nature of the mouths of rivers; and to the time, force, and duration of periodical storms, and their effect on navigation.

A general knowledge of the geography and topography of a country is, however, in itself insufficient for military purposes; it is necessary, in addition, to know the present state of roads and bridges, the depth and width of streams, the state of the soil and of its cultivation &c., and especially the best means of turning the ground to account for the object in view. This information is obtained by what are called Military Reconnaissances.

It is scarcely necessary to remind you that though mountain-ranges and rivers materially affect the operations of war, they are by no means insurmountable obstacles. The Alps have been repeatedly crossed since the days of Hannibal; Wellington crossed the Pyrenees in spite of the opposition of Soult, Diebitsch the Balkan though defended by the Turks; and Pollock forced his way through the dreaded Kyber; whilst there is hardly a river in the length and breadth of Europe that has not been crossed even when the passage has been ably disputed. Soult escaping from Wellington over the Sierra de Catalina by a smuggler's path, Ochterlony penetrating into the heart of the Goorkha country by a wild mountain track, the rear divisions of Napoléon's army at Leipsic sacrificed from a neglect to reconnoitre the Elster, show how close the examination of a country should be. This is, however, hardly the place, nor would there be time, to discuss the minuter details of military geography and topography; they will be found in the works especially devoted to the subject.

Queen Elizabeth's minister was right when he said that "knowledge is power;" and a knowledge of the physical features of a country, combined with a just appreciation of their influence on military operations, is a very great power in war. A commander entering upon a campaign without such knowledge may be likened to a man groping in the dark; with it he may act with a boldness and decision that will often ensure success. It was this class of knowledge, possessed in the highest degree by all great commanders, that enabled Jomini to foretell the collision of the French and Prussian armies at Jena in 1807, and in later years enabled a Prussian officer, when told that MacMahon had marched northwards from Chalons, to point unerringly to Sedan as the place where the decisive battle would be fought. Chief Justice Daly, in his address to the American Geographical Society, draws attention to the Franco-German War as "a war fought as much by maps as by weapons," and attributes the result to "skilful military movements, performed by an army thoroughly acquainted with all the geographical features of the country over which it was moved;" and, he adds, "It teaches us that if the fate of a nation may depend upon a battle, a battle may depend on a knowledge of geography."

As, then, all military operations must be based on a knowledge of the country in which they are to be carried on, it should never be forgotten that every country contiguous to our own (and the ocean brings us into contact with almost every country in the world) may be a possible theatre of war, and that it is equally the duty and policy of a good government to obtain all possible information respecting it. More especially is this the case with regard to the little-known districts, inhabited by uncivilized or but partially civilized races, that lie beyond the frontiers of many of our foreign possessions and colonies. Is it with much satisfaction that we can turn to the efforts made by this country to acquire that geographical knowledge which may be of so much importance in time of need? Though we had for years had military establishments on the Gold Coast, and though we had, more than once, been engaged in hostilities with the Ashantees, and might reasonably have expected to be so again, no attempt appears to have been made to obtain information about the country north of the Prah, or even of the so-called protected territories. The result was, that when the recent expedition was organized, the Government had to depend chiefly on the works of Bowdich, Dupuis, and Hutton (written some fifty years ago), and on a rough itinerary of the route afterwards followed by the troops, for their information relating to the country and its inhabitants. Nor is the Gold Coast an exceptional case: with settlements at Singapore and Penang we know absolutely nothing of the interior of the Malay peninsula, and not much of the adjacent islands. How little have the garrisons of Aden and Hong Kong contributed to our knowledge of Arabia and China! What advantage has been taken of the presence of the officers who have been in Persia during the last ten years to increase our knowledge of that country —knowledge which would be very useful at present in the unsettled state of the boundary questions on the northern and north-eastern frontiers? How little has been added to our knowledge of Afghanistan since the war in 1842! and what part did India take in Trans-Himalayan exploration before Messrs. Shaw and Hayward led the way to Yarkand and Kashgar?

It was with feelings of no slight satisfaction that many of us heard last year that the policy of isolation and seclusion which India appeared to have adopted, as the last soldier of Pollock's relieving force recrossed the Indus, was at last to be broken, and that an expedition, well found in every respect, was to be sent to Kashgar. It seemed an awakening from the long slumber of the last thirty years, during which we were content to stay at home in inglorious ease, resting under the shadow of the great mountain-ranges of Northern India, whilst we sent out Mirzas and Pundits to gather the rich store of laurels that hung almost within our grasp. Far be it from me to depreciate the valuable services of those gentlemen—services frequently performed at great personal risk and discomfort; but who can compare the results they obtained with those that would have been brought back by English officers, or by travellers such as Mr. Shaw, Mr. Ney Elias, and others?

If it be true (and few will be disposed to doubt it) that arctic exploration is one of the best schools for officers of the navy, it is equally true that exploration on shore is one of the best schools for officers of the army. The officer who has had for weeks or months to depend on his own resources, organizing his own commissariat and transport, fighting his way amidst hardship and discomfort against all difficulties, will be found to possess many of the most valuable qualifications for active service in the field; and not the least of these will be that eye for ground, or ready appreciation of relative height and distance, which often comes like a second sense to the explorer.

It has been said that if officers travelled in countries where Government could no longer protect them, they might be killed by the natives, and that then, if the murderers were not punished, England would suffer loss of prestige; but is this the case? Did any loss of prestige follow the murder of Conolly and Stoddart in Bokhara or of Hayward in the mountains of Gilgit? It is hard, too, to believe that the danger of loss of life has not been somewhat exaggerated when we find missionaries living for several years in comparative security at Coomassie; Maltzan, Halevy, and others exploring Southern Arabia; Ney Elias crossing China at a time when political circumstances made travelling more than usually unsafe; Prjewalsky, with six Kuzaks, wandering about China for nearly three years, and spending

several months on the northern borders of Thibet; Shaw and Hayward finding their way independently to Kashgar; and, finally, the Kashgar mission hospitably received not only by the Amir of Kashgar, but by the Kirghiz of the Pamir and the Mir of Wakhan. As a matter of fact, the number of travellers who lose their lives at the hands of the natives of the countries in which they are travelling is quite insignificant when compared with the number of those who return in safety. Let us, then, hope that the Kashgar mission may date the commencement of a new era during which geographical enterprise may be encouraged, or, at any rate, not discouraged, amongst the officers of the army; and that if few will now deny that a knowledge of Ashantee, of Yemen, of the northern and north-eastern frontiers of Persia, of Merv, Andkhui, Maimana, Badakhshan, and Wakhan would have been of importance in the year just passed, it may not be forgotten that a knowledge of these countries may be of still more importance in a not far-distant future.

May we not take a hint in this respect from our now near neighbours in Central Asia, the Russians? No one who has followed their movements can fail to have been struck by the intense activity of their topographical staff, an activity that can only be compared to that of England at the period when Burnes, Eldred Pottinger, Wood, Abbott, Conolly, and others, whose names are ever fresh in our memories, were penetrating into the wildest recesses of Central Asia. No sooner is Khulja occupied, than parties start out to examine the mountain-passes beyond; the capture of Sarmarcand is followed by an exploration of the Zerevshan valley; Khiva has scarcely fallen before detachments are out in all directions surveying the Amu and tracing the canals that give life to the oasis; rarely does a caravan start for Manas, Urumtchi, or any place of which little is known without an accompanying topographer. Persia has been traversed in various directions by members of the staff, and, as there has already been occasion to notice, Captain Prjewalski has found his way to the northern plateau of Thibet.

The records of the Royal Geographical Society and of the Geographical Section of this Association show how much has been accomplished by individual officers of the English army, too often without assistance; and that if encouragement were given to them there would be numbers of men able and willing to compete with the Russians in the great field of geographical exploration.

I pass now to a consideration of the contributions of war to geographical science; and amongst these it is perhaps hardly necessary that I should mention the very obvious manner in which military operations teach us geography by directing our attention for the time being to the country in which they are being carried on, or the direct geographical results that have followed many campaigns from the days of Alexander to our own. I have no doubt that last winter many persons whose previous knowledge of Ashantee was confined to a vague feeling that it was somewhere on the west coast of Africa, were following the course of the operations with intense interest on the maps issued by our geographical establishments: and if any one will take the trouble to compare the maps of Asia published fifteen years ago with those of the present day, he will see at once how much the cause of geography has gained by the Russian campaigns against the Khanates. The Russians are indeed far in advance of us in all that relates to those survey operations and that geographical exploration which should always be carried on simultaneously with the advance of an expeditionary force into an unknown or but partially known country; they have long since realized the importance, almost necessity, of accurate geographical knowledge based on sound systematic survey, and having learned, in time, the lesson that opportunities once lost may never be recovered, make every effort to take advantage of those that are offered to them. In the expedition against Khiva, each column had attached to it an astronomer and small topographical staff, whose duty it was to fix the geographical positions of all camps and map the route and adjacent country, whilst officers on detached duty were instructed to keep itineraries of their routes which might be fitted into the more accurate survey. On the fall of Khiva an examination of the Khanate was at once commenced; and it was even thought necessary to send Col. Skobelof, disguised as a Turcoman, to survey the route by which Col. Markosof should have reached the Oasis. It is much to be regretted in the interests of geography that some such system was not adopted during the

recent operations on the Gold Coast, and that so little, comparatively speaking, has been added to our knowledge of Ashantee and the Protectorate. The conclusion of peace with King Coffee, and the effect that must have been produced on the inland tribes by the destruction of Coomassie, appear to offer facilities for the examination of a new and interesting region, which it is to be hoped will not be neglected by those who are able and willing to take part in the arduous task of African exploration; and I trust that before many years have passed we shall know much more than we do at present about the Prah, the Volta, the great trade-routes leading from the coast to Central Africa, and of the open grassy country abounding in game which is said to lie between Coomassie and the lofty mountain-range called on our maps the mountains of Kong.

The most important military contributions to geography have undoubtedly been those great topographical surveys which are either completed or in progress in every country in Europe, except Spain, Turkey, and Greece. Frederick the Great was, I believe, the first to recognize that in planning or conducting operations on a large scale, as well as in directing many movements on the field of battle, a commander should have before him a detailed delineation of the ground of a whole or part of the theatre of war. To supply this want Frederick originated Military Topography, which, in its narrower sense, may be defined as the art of representing ground on a large scale in aid of military operations. It was found, however, that during war there was rarely sufficient time to construct maps giving the requisite information, and thus the necessity arose of collecting in peace such data as would enable maps to be prepared that should show the extent, relative position, and comparative height and steepness of mountain-ranges, as well as their connexion with each other, the course of the rivers, the direction of the main lines of communication, the position and importance of towns, the extent of morasses, forests, and other obstacles to the free movement of troops, and which at the same time should distinguish by different depths of shade those places over which troops could or could not be manœuvred.

In this necessity may be seen the origin of all national topographical surveys, including our own, which was commenced as a purely military survey in 1784 by General Roy, and transferred in 1791 to the old Board of Ordnance. The gradual development of these surveys, and the various stages through which they have passed before reaching their present state of excellence, need not be noticed here; but it may be remarked that, whilst in all foreign countries the topographical maps have retained their essentially military character, the Ordnance Survey maps have for many years past been constructed with the paramount view of their general utility to all classes in the kingdom, and the military character of our topographical map on the one-inch scale has had to give way to the civil requirements of the State. We find also on the Continent that the Cadastral surveys are conducted by a civil department of the State, the topographical surveys by the War department; whilst in our own country all operations connected with the Cadastral and topographical surveys are concentrated in one department, the Ordnance Survey, which since 1870 has formed part of a purely civil department of the State, the Office of Works.

Side by side with the large establishments engaged in the production of the topographical maps, there have grown up in most countries extensive departments, sometimes employing from fifty to sixty officers, whose duty it is to supplement the maps of their own and foreign countries by the collection of all information of whatever nature that may be useful in time of war, to arrange and classify the information thus collected, to prepare what may be called military-geographical-statistical descriptions of all possible theatres of war whether at home or abroad, to study the science of marches, the influence of ground on the movement of troops, the best and most rapid means of concentrating and moving large bodies of troops, and to plan campaigns under varied circumstances. The brief interval that elapses between the declaration of war and the commencement of hostilities, the rapid movements of armies, and the short duration of campaigns at the present day have shown more clearly than ever the imperative necessity of previous preparation for war; and the publication of the great surveys of most European countries has given an impetus heretofore unknown to the studies I have alluded to. In our own country

the Crimean war gave birth to a small topographical and statistical department; but only four years ago its staff consisted of but three officers, and even now it is hardly as large as one of the sections of its continental brethren.

The progress of the European surveys, and especially of our own, has been marked by many results which have indirectly influenced the advancement of geographical science. Amongst these may be mentioned the improvements in instruments made during the progress of the Triangulation, the invention of the Drummond Light, of Colby's compensation bars, &c., the connexion of the English and Continental systems of triangulation, the pendulum observations at various places, the measurement of arcs of the meridian, the comparison of the standards of lengths of foreign countries, of India, Australia, and the Cape of Good Hope, with our standard yard, which has recently been completed at the Ordnance Survey Office, Southampton, &c. In the same category may be placed the improvements in the art of map-engraving, in the application of chromo-lithography to the production of maps, as exemplified in the Dutch process of Col. Bessier and in the Belgian maps, and the employment of electrotyping to obtain duplicates of the original plates. By the latter process copies are taken of the engraved plates in different stages of their progress, and with different classes of information engraved on the different copies, which if mixed together would have confused them. Thus the one-inch map of England is published in outline with contours, with the hills complete but without contours, with the geology, &c. The art of photography has been largely employed in the production of maps, and its use is on the increase both in this country and on the continent, and especially in the Government Departments in India. The method of copying maps by photography without any error in scale or any distortion that can be detected by the most rigid examination was first proved to be practicable and was adopted in the Ordnance Survey Department in 1854 by Major-General Sir Henry James, for the purpose of facilitating the publication of the Government maps of the United Kingdom on the various scales. Since that date the necessity of rapidly producing, multiplying, enlarging, and reducing maps has tended towards the development of the various photographic processes which have been brought to a high state of perfection, such as photozincography, photolithography, heliogravure, Col. Avet's process used in Italy, papyrotype, &c. Some idea of the extent to which these processes are carried may be gathered from the fact that during the last five years photographic negatives on glass covering an area of 10,071 square feet were produced at the Ordnance Survey Office for map-making purposes alone, and from these negatives 21,760 square feet of silver prints were prepared and used in the various stages of the survey. An area of 959 square feet of the negatives was also used in producing 13,595 maps on various scales by the photozincographic process, which was also introduced by Major-Gen. Sir Henry James. It was by similar processes that the Germans were enabled to provide the enormous number of copies of the various sheets of the map of France required during the war of 1870–71.

The topographical maps of European countries vary considerably in scale, the manner in which the ground is represented upon them, and the style of their execution. Proposals have at times been made for the adoption of a common scale, but they have not hitherto met with much success; still, however, Sweden, Norway, Denmark, Prussia, Saxony, Switzerland, Italy, and Western Russia have each a map on a scale of $\frac{1}{100,000}$; and it is much to be regretted that Austria, when commencing a new map of the entire monarchy, did not adopt this scale instead of that of $\frac{1}{75,000}$. On the flat surface of a sheet of paper all inequalities of the ground must be represented conventionally, either by hachures, by contours, or by a combination of both: each system has its advocates, and the maps of foreign countries present examples of all; but it may be remarked that the use of contours is becoming much more general than it was a few years ago. Any comparison of the maps of the various countries would necessarily occupy much time, so I will only add that as specimens of engraving the sheets of our one-inch map are unrivalled, and that no foreign maps can compare for accuracy of detail and beauty of execution with the sheets of our six-inch survey. Our great national survey is the most mathematically accurate in Europe; and it speaks much for the ability of the officers who have

brought it to its present state of perfection, that from the very first they recognized the necessity of extreme scientific accuracy in their work, and that they have never had to withdraw from the position they have taken up with regard to the many questions of detail that have arisen from time to time.

Before concluding this portion of my address, I would draw your attention to the appliances used in the minor schools of this country for teaching geography, as they would seem to need some improvement. The subject is perhaps hardly one that comes within the province of the Royal Geographical Society, which has done so much to encourage the study of geography in our public schools; but it might well be taken up by one of the numerous Committees of the School Boards of our large towns. The appliances to which I allude are models or relief maps, wall-maps, atlases, and globes.

The use of models as a means of conveying geographical instruction has been too much neglected in our schools; if any one considers the difficulty a pupil has in understanding the drawing of a steam-engine, and the ease with which he grasps the meaning of the working model, and how from studying the model and comparing it with the drawing, he gradually learns to comprehend the latter, he will see that a model of ground may be used in a similar manner to teach the reading of a map of the same area. A teacher would probably find the same difficulty in enabling a pupil who had lived all his life in a level country, such as the great plains of Russia, to form from a map a mental picture of a great mountain-range, as in teaching one who had never seen a steam-engine to realize what it was and its mode of action from a simple drawing; the model in each case would form a connecting link.

Relief maps of large areas on a small scale have their uses, but they are unsuitable for educational purposes on account of the manner in which heights must be exaggerated to make them appear at all; this objection, however, does not apply to models of limited areas on a sufficient scale, which always give a truthful and effective representation of the ground. The difficulties attending the construction of accurate models, and their consequent cost, have proved serious obstacles to their common use in our schools; but models are readily built up from contoured maps, and the means of forming in this manner an instructive series of models of our own country, with ease, rapidity, and at slight expense, are quickly accumulating as the six-inch contoured sheets of the Ordnance Survey are published. Instruction in Geography should begin at home; and I would suggest that as the six-inch survey progresses every good school throughout the country should be provided with a model and map of the district in which it is situated. If this were done the pupils would soon learn to read the model; and having once succeeded in doing this, it would not be long before they were able to understand the conventional manner in which topographical features are represented on a plane surface, and acquire the power of reading, not only the map of their own neighbourhood, but any map which was placed before them. With these models topographical studies, which might be the same for all schools, should be supplied, such as a representation of a coast region, a mountain-lake with surrounding hills, a volcano, or an alpine district with glaciers; and it would add much to their value if they were accompanied by bird's-eye views and landscape sketches. In Switzerland nearly every school has a model of the country; in Austria, France, and Germany models are largely employed for instructional purposes; they have long been in use in our military schools and colleges; and models of the environs of Plymouth with corresponding portions of the six-inch map are used somewhat in the manner I have suggested. The demand for models on the Continent has naturally resulted in their extensive manufacture; and some good specimens have been produced by Delagrave of Paris, Wagner of Berlin, and others; but they do not give all that is required, and are capable of much improvement.

In our Wall-Maps I think we have been too much inclined to pay attention to the boundaries of countries, and to neglect the general features of the ground. It is difficult to say whether the maps have followed the teachers or the teachers the maps; but I fear instruction in physical geography too often comes after that in political geography, instead of a knowledge of the latter being based on a know-

ledge of the physical features of the earth. My meaning may perhaps be explained by reference to a wall-map, probably well known to every one, that of Palestine, which frequently disfigures rather than ornaments the walls of our school-rooms. In this map there are usually deep shades of red, yellow, and green, to distinguish the districts of Judæa, Samaria, and Galilee, and perhaps another colour for the Trans-Jordanic region, with a number of Bible names inserted on the surface, whilst the natural features are quite subordinate and sometimes not even indicated. There is, perhaps, no book that bears the impress of the country in which it was written so strongly as the Bible; but it is quite impossible for a teacher to enable his pupils to realize what that country is with the maps at present at his disposal. How little distinction is made on the maps between the great corn-growing plains of Philistia, the vine- and olive-clad hills that stand round about Jerusalem, the deep depression of the Dead Sea, and the pasture-lands of the Moabite plateau! and how little do they bring out those peculiar features which in a country the size of Yorkshire enabled the Psalmist to be familiar at the same time with the snows and alpine flora of the Lebanon and Mount Hermon, and with the intense heat and tropical vegetation of the Jordan valley.

The first object of a wall-map should be to show the geographical features of countries, not their boundaries; and for this purpose details should be omitted, and the grander features have special attention paid to them. Many attempts have been made in this direction on the continent, by representing the ground by contours, or by zones of altitude distinguished by tints, more or less deep, of the same or different colours, by giving prominence to rivers, coasts, &c., by reducing the importance of names by writing them small, and by inserting dotted lines instead of bright colours to mark boundaries. None of these attempts have been quite successful; but they indicate progress in the right direction, and are deserving of attention in this country.

In school atlases the same fault may be traced, physical features being too often made subordinate to political divisions; and there is also in many cases a tendency to overcrowd the maps with a multitude of names, which only serve to confuse the pupil and divert his attention from the main points.

The use of globes in our schools should be encouraged as much as possible, as there are many physical phenomena which cannot well be explained without them; and they offer far better means of conveying a knowledge of the relative positions of the various countries, seas, &c. than any maps. If a pupil once learns from a globe the places traversed by the principal parallels and four or eight equidistant meridians, with the most important places near their points of intersection, he will find more than half his difficulties overcome. The great expense of globes has hitherto prevented their very general use, but some experiments are at present being made with a view to lessening the cost of their construction, which it is hoped may be successful.

I cannot pass from this subject without alluding to that class of map which gives life to the large volumes of statistics which are accumulating upon us with such rapidity. On the continent these maps are employed to an extent unknown in this country, both for purposes of reference and education, and they convey their information in a simple and effective manner. Amongst them may be noticed maps showing the administrative, historical, and statistical features of Germany, the distribution of religious professions in Russia, the industrial maps of the same country, the agricultural maps of Austro-Hungary, &c. Several interesting maps of this nature were exhibited at Vienna last year, one of which may be noticed as illustrating the statistics of the coal-trade in Germany, showing at a glance the districts supplied by each separate coal-field and by imported coal, as well as the proportion of home and foreign coal consumed in those places where there is competition.

I will only detain you to notice briefly a few of the most important geographical events of the year; and foremost amongst these ranks the publication of Dr. Schweinfurth's work, which every one has recently been reading with so much interest and pleasure. Dr. Schweinfurth, who received the Founder's Medal of the Royal Geographical Society this year, is, I am happy to say, amongst us at present, and has contributed a valuable paper on the oases of the Libyan Desert. Dr. Gerhard Rohlfs is preparing an account of the remarkable journey which he made

last winter in the unknown parts of the Libyan Desert, one of the features of which was a march of thirty-six days between Dakhleh and the oasis of Jupiter Ammon without finding a single well. Sir Samuel Baker's record of the expedition from which he has recently returned will shortly be published; and the journals of Dr. Livingstone, which form a most important contribution to geographical knowledge, are being prepared for publication by his son.

Africa.—Lieutenant Cameron, R.N., has reached Ujiji, and extracts from a journal which he has sent home will be read to you; the observations which he has made are of high value, and the presence of a trained surveyor on the shores of Lake Tanganyika cannot fail to be followed by great results. A short report of Dr. Nachtigal's travels has been prepared for this Section; and Dr. Rowe, who acted as Chief of the Staff to Sir John Glover during his recent operations on the Gold Coast, will read an interesting paper on the country passed through on the march to Coomassie, and thence to the coast. Two engineer officers, Lieutenants Watson and Chippindall, have recently left England to join Colonel Gordon at Gondokoro, with the special object of surveying the territory over which Colonel Gordon has been appointed Governor by the Khedive. As the officers are well supplied with instruments, &c., most important results, including, I hope, a survey of the Lake-district, may be expected from their labours. Of Colonel Gordon's progress a few notes will be communicated to you. In Algeria the French have been actively engaged on the survey of the country, and the exact level of the Chott Melghir has been determined. Mr. Stanley's second expedition to the east coast of Africa, under the auspices of an English and an American newspaper, should not remain unnoticed; and I cannot pass from Africa without expressing my deep regret at the death of Dr. Beke, whose travels in Abyssinia were rewarded by the gold medal of the Society, and whose observations in that country were, from their great accuracy, of so much service during the Abyssinian war.

Asia.—The survey of Palestine (a work which has been said by a distinguished German geographer to mark the commencement of a new era in geographical research) is progressing favourably, and has led to the formation of an American Society for the exploration of the country east of Jordan, which has already done good service in the field, and of a German Society for the exploration of Phœnicia. The Rev. Dr. Porter, from whose labours in Palestine every one who has visited or takes an interest in the country has derived so much profit and pleasure, will read a paper on the lesser-known parts of Eastern Palestine, which he has recently visited, and a paper on the progress of the survey has been prepared by Lieut. Conder, R.E., the officer in charge. Our own survey is, I regret to say, languishing for want of funds, whilst that of the Americans is receiving that support from the people which it deserves; the serious loss which the fund has experienced in the death of Mr. Drake, who recently succumbed to an attack of fever at Jerusalem, and who had previously devoted his best energies to the work, must be still fresh in your memories. Lieut. Gill, R.E., who accompanied Col. V. Baker last year on a tour to Meshed and the head waters of the Atrek, has prepared an account of their journey, which will be found to contain much information on the important questions connected with the north-eastern frontier of Persia. Some most interesting particulars of the visit of a portion of Mr. Forsyth's mission to the Great Pamir and Wakhan have been kindly supplied by Col. Biddulph, R.A., from letters received from his brother, Captain Biddulph. The vast importance of this journey, both as regards the geography and topography of the Pamir, and the light which it throws on the boundaries of Wakhan, cannot be exaggerated. The success of the party has, however, been purchased by the loss of Dr. Stoliczka, who died from the effects of fatigue and exposure within a few marches of Leh. Mr. Delmar Morgan has prepared a very valuable paper on early Russian exploration in Central Asia, which will be found to be of great interest; and Mr. MacGahan, the enterprising correspondent of the 'New York Herald,' whose adventurous journey across the Kyzil-kum desert obtained for him, from the Russians, the title of *molodyetz* (a brave fellow), has forwarded some interesting details relative to the geographical work of the Khivan Expedition.

The Russian scientific expeditions for the exploration of the delta of the Oxus, the old bed of the Yany Darya, and of the Aral-Caspian steppe have been for some

time at work, and will doubtless collect sufficient data for the solution of the many interesting questions connected with the former courses of the Amu and the Syr. As an English officer (Major Wood, R.E.) is said to have accompanied one of the expeditions, we may hope for early information respecting the results of the expedition. Amongst the features of the year is the number of interesting works either published or about to be so: works by Mr. MacGahan on the Khivan Campaign, by Sir F. Goldsmid on Persia and the Persian Telegraph have appeared; and we are promised works on Central Asia by Mr. Dilke and Mr. Schuyler. Capt. Prjewalski is engaged on an account of his journey to Thibet, and the Russian Government are preparing an official account of the Khivan campaign.

In Australia the great geographical event of the year has been Colonel Warburton's journey from Alice Springs, near Mount Stuart, on the line of overland telegraph, to Rocbourne, in Nickol Bay, for which he was awarded the Patron's Gold Medal of the Royal Geographical Society. Such particulars of the journey as have been forwarded to me through the courtesy of the Colonial Office and of Mr. Dutton, the Agent-General for South Australia, will be communicated to you. By the latest accounts Mr. Forrest, whose name is so well known in connexion with Australian exploration, had left the hitherto explored parts of Western Australia for the Central Telegraph line. Mr. Forrest's route was to be from Champion Bay by Mount Luke to Mount Gould on the Murchison River.

An account of the travels of Mr. Miklucho-Maclay, the Russian naturalist, in New Guinea has recently been published at St. Petersburg, and will, I hope, appear in an English form, as the importance of New Guinea, lying on what will be the great trade-route from Australia to China, is daily becoming more apparent.

In America, whilst the coast and inland surveys have been progressing, Dr. Haydon, who was the first to disclose to us the strange beauties of the Yellowstone region, has been engaged in exploring a country equally wild and picturesque, the eastern half of Colorado, where a vast number of sandstone peaks, presenting an extraordinary variety of form and colour, rise up to heights of from 12,000 to 14,000 feet. Other expeditions have been doing good service in the Yellowstone country, Arizona, Oregon, and the Aleutian Islands, amongst them one sent out by Yale College, which, besides exploring new country, brought back five tons of specimens from the great fossil beds of Oregon and other places for the College museum. I cannot help thinking that in sending out these expeditions (for this is only one of a series) for the examination of the geography, geology, botany, zoology, &c. of some special district, Yale College has set an example which might well be followed by our own universities, and that Dublin, Oxford, and Cambridge might take more part than they have hitherto done in what may be called scientific exploration in the field. In the north the survey of the interoceanic railway through British territory has been completed, and my old friend and fellow traveller Captain Anderson, R.E., has been engaged, as chief astronomer of the International Boundary Commission, in running the forty-ninth parallel through the unknown country between the Missouri and Saskatchewan, and a short account of the demarcation of the parallel and the country through which it passes will be read to you. In the south Commanders Lull and Selfridge have found practicable routes for ship-canals, from Greytown by Lake Nicaragua to Brito on the Pacific, and by way of the Atrato from the Gulf of Darien to a point near Cupica on the Pacific; the cost of the latter is estimated at twelve million pounds.

In South America Professor Orton has been extending our knowledge of the Amazon country; and I may mention the activity which the Peruvian Government are showing in promoting the exploration of the little-known districts of Peru. Mr. Hutchinson, late Her Majesty's Consul at Callao, will read a paper "On the Commercial, Industrial, and Natural Resources of Peru," which will be found to contain much interesting information respecting that country.

Dr. Carpenter will, I hope, give us some account of the cruise of Her Majesty's ship 'Challenger,' which cannot fail to interest the people of this town from Professor Wyville Thomson's former connexion with it.

Captain Warren, R.E., whose name is so well known from his work at Jerusalem, has forwarded a valuable paper "On Reconnaissance in Unknown Countries;" and Captain Abney, R.E., will read one on a subject which he has made pecu-

liarly his own, the "Application of Photography to Military Purposes." Monsieur Maunoir, the Secretary of the French Geographical Society, has forwarded a paper "On the Objects to be obtained by the International Congress," to be held at Paris in the spring of next year, to which I would especially direct your attention; and an interesting communication "On the Ordnance Survey of Ireland" and the "Uses to which the Maps are applied" has also been received.

I regret that I am not able to give any definite information on the probability of Government assistance to Arctic exploration; but I understand that the impression produced on the members of the deputation which recently had an interview with the Prime Minister on the subject was that he was not unfavourable to such assistance.

Admiral Sherard Osborn has kindly forwarded a paper on "Routes to the North Pole;" and Lieut. Chermside, R.E., who accompanied Mr. Leigh Smith last year on a very remarkable voyage to Spitzbergen, will read an account of the discoveries they were enabled to make.

The reports of the officers of the 'Polaris' have been published, expressing contradictory opinions as to the possibility of their having been able to reach a higher latitude. As regards the general subject of Arctic exploration, there can, I think, be no doubt that that by Smith's Sound would yield the most important scientific results, and would at the same time offer great facilities for reaching the pole itself. It should not be forgotten that all recent Polar expeditions sent out from this country have been despatched with the special object of ascertaining the fate of Sir John Franklin, and that discovery was not a principal object. When, too, we consider that in these expeditions Arctic travel was reduced to a very perfect system, that the distance from the point reached by the 'Polaris' to the Pole is less than has already been performed in some of the sledge-journeys, and that no life has ever been lost on a sledge-journey, it is impossible to doubt that a well-organized expedition would be able to reach the polar area. In the words of a well known arctic explorer, "What remains to be done is a mere flea-bite to what has already been accomplished." Morton, the second mate of the 'Polaris,' says, as the result of his third voyage, that he is "more than ever convinced of the practicability and possibility of reaching the Pole;" and if I may express my own opinion, it would be, in the words attached to a picture at the last Exhibition of the Academy in London, "It is to be done, and England ought to do it."

The Routes to the North Polar Region.

By Rear-Admiral Sherard Osborn, *C.B., F.R.S., &c.*

In this paper the additional 120 miles towards the North Pole reached by the last American Expedition under the late Captain Hall of the 'Polaris,' *viâ* Baffin's Strait and Smith's Sound, were urged as a new and cogent argument in favour of the sending out of another Arctic Expedition by the British Government in the same direction. Pointing out that the Polar Sea comprised within the 70th parallel of latitude leaves a space of 2400 miles wide (about equivalent to the distance from England to Halifax), and that a line through the pole from Grinnell Land, in America, to Cape Taimyr, in Asia, is only half the distance of the route from Spitzbergen to Behring's Straits, the author relied on the saving of 800 miles of unknown land or sea as his chief reason for advocating the former way. As additional arguments for this selection of a passage through the American archipelago, he remarked that the European Arctic islands may be fairly deemed to end 120 miles north of the Spitzbergen group, whilst the few Asiatic islands are not known to occur nearer than 15° of the Pole; that the northern lands of the western hemisphere have been traced up to the 84th parallel (or *sighted* to that supposed distance), within 360 miles of the Pole, and with no symptom of termination; and that Greenland itself, up to 83° on the western and 77° on the eastern side, has been found to abound with animal and vegetable life. He also noticed the long and deep channels, mostly north and south or east and west, dividing the American group—Smith's Sound (1600 miles, so far as yet explored) being noted as the longest strait known, and the continuous southerly motion of ice down the

latter pointing to the existence of a great polar ocean whence the drift of ice (and of wood, as seen by the crew of the 'Polaris') issues, there being no other adequate outlet. To avoid this enormous outpour of ice, Admiral Osborn would follow the Greenland coast on the western shore, trusting to find himself, during the brief Arctic summer, in a comparatively navigable sea near the pole, across which Asia might be reached. Other proposed routes were once more discussed and rejected, the earlier ill-starred German Expeditions being especially condemned, though great praise was given to the crew of the 'Hansa' (whose commander, Koldewey, now agrees with the author as to Smith's Sound being the only practicable route). The statement that Hall's crew sighted land in the 84th parallel was thought likely to be correct, because arctic lands asserted to have been sighted on former occasions have always been reached subsequently.

In reply to the question "*Cui bono?*" on arctic routes generally, Admiral Osborn relied on the peculiar scientific value attaching to observations made in the polar area, whether mathematical, meteorological, hydrographical, or botanical (in the latter case especially as regards palæontology); and he claimed the support of the Royal Society and its learned President, Dr. Hooker, in these opinions.

On Mr. Leigh Smith's Voyages to Spitzbergen.
By HERBERT CHERMSIDE, *Lieut. R.E.*

This paper was divided into the following sections:—I. On the track and outline of Mr. Leigh Smith's three voyages to the Spitzbergen seas; II. On the hydrography of the Greenland Sea; III. A survey and physical sketch of Spitzbergen and the sea to the east. In the first voyage, in 1871, the most favourable season was encountered. The north-eastern portion of Spitzbergen was found to be of nearly double its supposed extent; but, unluckily, want of preparation for an Arctic winter and the lateness of the season put an end to further exploration. In the second voyage, in 1872, attempts (unsuccessful for want of steam-power) were made not so much along the land as to penetrate the polar pack. In the third, a steamer was used for exploring and a sailing-ship as the reserve; but the unfavourable state of the ice prevented the former from penetrating beyond lat. 81°, her most interesting work being the exploring of the unvisited portion of the north-east land, and the relief of the Swedish Government Expedition, found frozen-in in one of the bays on the northern coast. The author described the conditions of air and water in the Greenland Sea, illustrating by temperature soundings the probability of finding in some seasons navigable water leading to very high latitudes. He especially referred to three routes by which attempts at navigation might be made, viz. along the west coast of Spitzbergen, the east coast of Greenland, and the east coast of Spitzbergen; but was of opinion that the two latter are more adapted for wintering and spring sledge-expeditions, owing, in the former case, to the ice-encumbered state of the sea and the narrow and quickly closed channel along the land, and in the latter to the shoal depth of the sea and the almost certainty of land or an ice-barrier, the cessation in the summer of the southward flow hardly encouraging the idea of a navigable channel in this direction. He also made some observations on the glaciers of Spitzbergen, all of which he proved to be more than sixty years old, and on the lowness of the snow-line, and its probable causes. Striking examples were adduced of the rapidity of upheaval now going on, illustrated by the depths found around grounded bergs, the heights of which were measured, and the immense distances inland and heights above the water at which whale-bones and drift-wood (but little decayed) were discovered. He was of opinion that the whole of the recent additions to the north-east land were, at no more distant period than the sixteenth century, under the sea; and this idea he supported as well by these evidences of upheaval, as by the changes to be found between the land as it now exists and as represented in the old Dutch charts.

The author objected, from his own observations, to the theory that circulation is due to difference of temperature alone, asserting that it is owing to difference of salinity as well as of temperature. According to him, the water on the west coasts

of Spitzbergen and Nova Zembla is of a temperature far above the normal one of the latitudes, and the isotherms below the surface are higher with increasing depth in many places in the Arctic Ocean; but here, owing to the sea shoaling near the land against which the currents are forced by the earth's rotation, they rise rapidly to the surface, producing its high temperature and the comparative mildness of the climate found on those coasts. In the deep sea of the Arctic Ocean the warm water is found below, being a northward flow of equatorial water of sufficient salinity to outweigh the brackish polar water, even at a comparatively high temperature. As evidence of such water being equatorial, he observed that where, as off Spitzbergen, it is found at the surface, it is heavier than that of the seas both to the east and west, these results being the mean of daily observations with delicate hydrometers. The northward set of the current from distant latitudes was illustrated by the fact of a bean of a pod-bearing plant of the Gulf of Florida having been found on the coast of Nova Zembla, and numerous objects, evidently drifted from Norway, on the Spitzbergen coast. The agreement of the deep-sea temperature observations of Mr. Leigh Smith's three cruises, during which the same route was twice travelled over, was shown to be very close in many cases; these, again, according in a remarkable way with those of early explorers, the maxima in identical localities being usually rather less in the recent soundings, as might be expected from the use of protected thermometers. The possibility of a warm current plunging under ice and reappearing is suggested by the open water found on the west coast of Spitzbergen in the depth of winter, and separated from that of the Norwegian coast by a barrier of ice often more than 250 miles wide. This current, as Lieutenant Chermside presumed, may run in a submarine stratum to the north-west corner of Spitzbergen; and he was of opinion that if any land exist to the north-east, there must here again be a surging up of the warm waters against the coast, and a consequent chance of navigation in summer.

On the Results of the 'Challenger' Researches into the Physical Conditions of the Deep Sea. By WILLIAM B. CARPENTER, *M.D., LL.D., F.R.S.*

The author referred to the Lecture delivered by him "On the Temperature of the Atlantic" at the Royal Institution of Great Britain on 20th March last, and to another delivered before the Royal Geographical Society (*vide* no. iv. of vol. xviii. of the 'Proceedings,' "Further Inquiries on Oceanic Circulation"). The subject was brought forward as being of special interest to the Belfast public, from the circumstance that Professor Wyville Thomson, head of the scientific staff, was long resident among them, and that it was in their city the subject was originally started. The author publicly admitted the priority of Lenz in his theory of oceanic circulation.

On the Demarcation of the International Boundary between Canada and the United States (1872–73). *By* Captain S. ANDERSON, *R.E., Chief Astronomer N. A. B. Commission.*

A detachment of 44 Royal Engineers left Liverpool on 22nd August, 1872, and reached the frontier at Pembina on 20th September. Here astronomical and surveying parties were organized, and whilst the former determined the boundary-line at points 20 to 30 miles apart by zenith-telescope observations, giving a result with a probable error in latitude of 10 feet, the latter surveyed the country for a distance of from 6 to 15 miles north of the boundary. During the winter the parties were at work between Red River and the Lake of the Woods, for in that swampy country (the nature of which is sufficiently well known from the surveys of Dawson and other Canadians) that season is most favourable for such operations. Besides the observations indicated, the longitude of Pembina was carefully determined by electric telegraph, a series of instrument-levels was carried along the boundary, and magnetic and meteorological observations were taken.

In the summer of 1873 the survey to the westward of the Red River was begun; and as the country had not previously been explored, it was deemed advisable to organize a reconnaissance party, for the purpose of selecting camps,

establishing depôts, &c. Owing to the necessity of carrying supplies, including even wood and water, the total strength of the Commission was raised to 275 persons. In the course of that season 437 miles of boundary were surveyed, the latitude and longitude of 38 points ascertained, 10 principal astronomical stations determined by zenith observations, and meteorological, magnetic, and barometrical observations made. At Pembina, the Red River is 75 yards wide, 10 feet deep in summer, and 752 feet above the sea. From this point westward the boundary crosses 35 miles of fertile alluvial prairie land; it then traverses for 12 miles the rugged and wooded Pembina mountains and enters the Great Plains (1400 feet above the sea). These plains have a poor soil, granite boulders are scattered about, and patches of luxuriant grass are met with only in hollows. Supplies of wood or water cannot here be depended upon for 68 miles. These plains are altogether unfit for agricultural purposes, though available as pasture. By an ascent of 200 feet, the boundary then enters the Turtle Mountains, well wooded and full of little lakes; and after 34 miles again emerges upon the open plain, which it traverses for 138 miles further west, at an average elevation of 2000 feet. The soil here is sandy, and the scanty bunch-grass only affords pasture for a few herds of antelopes. At a distance of 280 miles from the Red River the plain ceases, and by a gradual ascent of 250 feet enters upon the Great Côteau, a prairie extending north and south, and leads to a remarkable plateau (2250 feet) composed of a series of irregular ridges which extend for 33 miles, when the boundary traverses for 15 miles a district of alkaline lakes, the white deposits from which contrast strangely with a bright crimson plant growing on their margins. After this the boundary enters the basin of the Missouri, the soil becomes clayey and very friable and is cut up by rain into deep ravines. Leaving this rugged district after 30 miles it enters a more undulating country (2300 feet). Lignite coal, in seams 2–5 feet thick and available as fuel, was found here, but very little wood. The character of the country continues the same for 70 miles, the extreme reached. Buffaloes were rarely met with, as within the last fifteen years they have migrated from the vicinity of the Red River to the country 600 miles west.

The surveying parties suffered much from mosquitoes and from violent thunder-storms, which converted the plain into a vast lake in June and July, followed by six weeks of drought, when prairie-fires frequently occurred. On 22nd September the equinoctial snow-storms set in from the north-west, lasting for five days. In spite, however, of these unfavourable climatic conditions, the health of the working parties continued good.

It would appear from the Report (which was accompanied by maps and photographs) that, excepting a small tract in the immediate vicinity of the Red River, the country explored holds out no inducements to settlers.

On the Oases of the Lybian Desert. *By* Dr. G. Schweinfurth.

After referring to the small knowledge hitherto possessed of the Lybian Desert, and the recent additions to it by Nachtigall and Rohlfs, the author described his own exploration of the great oasis El-Khargeh (the outer), distinguished from Dakkel (the inner), the basis of Rohlfs's expedition, three days' journey further westward. He reached the capital of this outer oasis (of the same name) in January, after five and a half days' march (190 kilometres, almost south) from Sivot. At the end of April he returned to the shores of the Nile *viâ* Girgeh, the result of his journey being a triangulation on a measured basis of 3½ kilometres. The oasis is 120 kilometres in length, and so formed as to resemble the bottom of a gigantic valley, the width of which appears very much to exceed the Nile at its broadest. On the north and east it is bounded by mountains detached from the Lybian plateau, composed above of hard, brilliant, red nummulite chalk, and below of chalk of dazzling whiteness. As a whole, it is not uninterruptedly verdant, being of the usual monotonous yellow, but with black and green spots. These little islands, as it were, are the arable portions, the springs surrounded by acacias, the fields, palm-groves, brooks, and ponds. He dwells with animated language upon the pleasure excited by the undulating plains, bubbling watercourses, and

terraces of vegetation of these enchanting spots. The ten inhabited portions are stated to have 5700 inhabitants, dwelling in restricted and fortified situations, owing to their continual dread of surprise by Tripolitanian hordes. In Khargeh itself the houses are absolutely built over the streets, being, as it were, on piles supported by rough beams, through which the inhabitants grope in a stooping posture. Though using a language differing but little from that of the modern Egyptians, they betray no facial characteristics of the latter, being apparently the remains of one of the numerous Lybian races of the hieroglyphical Berber nations, of more northern extraction. They are of signally livid complexion, owing to prevalence of fever from miasma. Vaccination is enforced. They are lax in their observance of the rules of the Prophet, and do not possess a single trace of Christian tradition. Five large temples (500 years B.C.), seven Roman castles, hundreds of wells, the Necropolis of Hibe, and other remains testify to the great former prosperity of the oasis. Close to Doosh is the dwelling of a commander in the time of Trajan, in excellent preservation. The (Christian) Necropolis of Hibe is in wonderfully perfect condition. Its construction deviates entirely from Egyptian models, and follows the Roman rather than the Greek style. Embalming was certainly practised here by Christians of the first five centuries. The various inscriptions on rocks, dating through a series of epochs, afford a strange picture of the slowness with which time effects transformations of surface. Seventy-five springs, all of the earliest antiquity, are in use, and no new ones are ever opened. They are periodically cleaned by divers, at the risk of their lives, for a few copper piastres. An Egyptian engineer has, however, found water at 60 to 100 metres in the Dakhel oasis; and there is no doubt that the district could be restored by artesian wells to its former prosperity. The author thinks it least improbable that the water has its source in the Nubian Nile, probably above the cataracts of Wady Talfa; but he seems to doubt all the explanations attempted for its origin, by stating that all these springs are thermal, far exceeding the average temperature of the year, and consequently of the upper strata of the Sahara. There are no traces of a bed of a former current from the Egyptian Nile valley westward through which the Nile might have flowed, although an imaginary series of oasis valleys figures in all maps. It is strange, nevertheless, that "Bader-bela ma" (*i. e.* river without water) is a frequent local name for valleys and sandy wadys. The soil of the oasis chain betrays no traces of the clay alluvial land of the Nile, there are no fish in any of the waters, and the botanico-geographical facts recapitulated by the author also negative the idea of the Nile having ever flowed here. After entering upon the various geological features of the district at some length, he thinks it safe to assume that the subterranean water of the oasis is equal to that of a first-class river. The scheme of irrigation is primitive, neither draw-wells nor wheels being known, and much is wasted, becoming impregnated with salts from some of the strata; and these salts, and the encroachment of quicksands, which usurp the finest parts of the oasis, are very prejudicial to cultivation. The sand hills are continuously advancing from north to south, with a gentle inclination westward, forming a crescent-like arch. The largest are in Dakhel, where they are insurmountable by camels, and prevented Rohlfs's advance. All Egyptian plants, except the hog's bean, are found in the oasis, many cereals being cultivated, and rice and barley especially thriving. The date is naturally the staple of the agriculturist, and the bearing trees are estimated at 80,000, taxes being levied on the number of trees and the area of the cultivated soil. One tree, sixty years old, with sixfold ramifications of long shooting branches, is stated as probably not to be matched in the whole world. The camel cannot be acclimatized, owing to the damp summer miasma and plagues of midges; but donkeys, cows, buffaloes, and sheep are easily reared. The indigenous mammalian fauna is extensive (including five carnivora); stationary birds are few, but migatory birds abound, though, singularly enough, neither ducks nor geese are found in the waters of the oasis. All the oases on the east of the Lybian desert have the same flora, and the explored part yielded 225 species, which would probably only be increased by one fourth if more thoroughly worked. Nearly half of them are connected with the culture of rice. Even in its most torpid state, the soil appears nowhere wanting in vegetable germs.

Dr. G. Nachtigall's Explorations in Africa, 1869–74. *By* E. G. Ravenstein, *F.R.G.S., F.S.S.*

The German Emperor having resolved to forward to the Sheikh of Borneo a number of valuable presents, in recognition of the kindness shown by that potentate to several German travellers who had visited his country, Dr. G. Nachtigall, at that time body-physician to the Bey of Tunis, volunteered to accompany them. A long residence in Northern Africa, and a thorough knowledge of the language and the customs of the country, peculiarly qualified him for the duty he had undertaken. Furnished with mercurial barometers, aneroids, a hypsometer, and thermometers, he left Tripoli on the 18th February, 1869, and, following the usual road *viâ* Sokna, arrived at Murzuk on the 27th March. The caravan traffic between Murzuk and Borneo having been interrupted in consequence of raids undertaken by the Welad Sliman against Bilma, and there being no immediate prospect of its being resumed within a reasonable period, Nachtigall determined to employ his enforced leisure by paying a visit to Tibesti, an oasis of the Eastern Sahara inhabited by the Tibbu Reshade, and never previously visited by a European. He left Murzuk on the 6th June, and after thirty-six days' journey reached Tao, the first inhabited spot of that oasis. At the time of Nachtigall's visit most of the inhabitants had retired to the hills or to Bardai, a fertile valley beyond the lofty mountain-range which intersects Tibesti from north to south. The traveller's reception was by no means favourable; but he nevertheless persevered, and passing a remarkable extinct crater and a mountain pass 6700 feet in height (the highest mountain of the district attaining an altitude of 7900 feet), succeeded in making his way to Bardai. But there he nearly fell a victim to an infuriated mob, and only owed his life to the kindness of one of the most influential chiefs of the place. Kept a close prisoner and unable to explore the country, Nachtigall, after a month's detention, sought safety in flight, and, after undergoing indescribable hardships, reached Murzuk in safety on the 8th October. On the 18th April he was able to start for Borneo, the capital of which he reached on the 6th July, 1870. The Sheikh received him with the greatest kindness, and facilitated his proposed geographical researches in every way. Nachtigall first directed his steps to the N.E., to Borku, a district to the south of Tibesti, and also not before visited. This journey resulted in the remarkable discovery that Lake Tsad at some former period discharged a river in a north-easterly direction, which emptied itself into a vast lake, at that time filling the depression of Bodele. Numerous skeletons of fishes, &c. testified to the existence of this ancient lake; and even now, after unusually heavy rains, Lake Tsad is stated to discharge a river in that direction. After his return to Kuka, Nachtigall started for Bagirmi, to the exploration of which he devoted the time between the 27th February and 9th August, 1872. He unravelled the complicated hydrography of the Shari and its tributaries, and added much to our knowledge of the heathen tribes dwelling in the far south, a savage though industrious race, who are constantly exposed to the slave-hunting raids of their Mohammedan neighbours. Nachtigall himself witnessed some of the most horrid scenes of the traffic in human beings, and does not hesitate to charge the Turkish authorities in Tripoli and Fezzan with conniving at it. In the beginning of March, 1873, he finally left Kuka for the purpose of returning to Europe by way of Wadai, Dar Fur, and Nubia, and this object he will in all probability accomplish; for when last heard of, on the 13th March, 1874, he was already at the capital of Dar Fur, and money forwarded to him from Khartum had safely reached him.

On Sir John Glover's Expedition from the Volta to Coomassie. By Surgeon-Major S. Rowe, *G.M.G., Chief of the Staff to the Expedition.*

The author gave a description of the position and political relations of the tribes in the eastern division of the Gold Coast Territory intended to be raised and trained by the Glover Expedition; also of the Trans-Volta tribes, and a short attack of the Ashantees on Krepee in 1869, and the capture of the German missionaries. He referred to the treaties made in 1869 by British authorities with the

Aquamoos, and to the successful attack on the piratical island of Duffo in 1870; and then described the confidence of the Haussas and Yorubas in Sir J. Glover, and their arrival from Lagos to join him; the assembly of the Beach tribes at the mouth of the Volta at Addah Fort, and of the Aquapims, Crobboes, and Crepees at Blappah under Major Sartorius, the crossing of the Volta (23rd to 25th December), and the successful fights at Farah and Adidoomay. He then alluded to the causes of Sir J. Glover's return over the Volta, and described the incidents of the march through Crobboe, Aquapim, and Akim to Ashanti, with the crossing the Prah on the 15th January, and the taking of Abogoo, Bangsoo, Towassy, Connummo, and Odsomassie, and the different attempts made to communicate with the main body under Sir Garnet Wolseley—amongst them, the passage of the Anoon river by Sartorius. The presence of Sir Garnet's force in Coomassie was communicated by two fugitive slaves from Boankra. After breaking all communication with their rear, the column marched forward, arriving at Essidnimpon, where Major Sartorius set off to open communication with the main body. The author then described the arrival of the Glover column in Coomassie, the appearance of that town, and the dissatisfaction of the native contingent at leaving it so hurriedly. He sketched the return map to the coast, and summed up the assistance rendered, in his opinion, to the main body by the operations of the contingent. The languages of the native allies, the products of their country, their style of living, and the supply of gold were briefly mentioned.

East-African Expedition. Extracts from Lieutenant CAMERON'S *Journal.*

The portion read (which had then just come to this country) included the details of Lieut. Cameron's journey from Kwihara (Unyanyembe) on the 11th November, 1873, to his arrival at Kawele (Ujiji) at the end of March, 1874, the chief object of his explorations being the recovery of the journal and map reported by Livingstone's men to have been left at the latter place. Various circumstances delayed the regular prosecution of this journey until the 2nd January, 1874, when Lieut. Cameron started on a line between the routes taken by Burton and Stanley, skirting the territory of Mirambo, a chief who is much more powerful than the Arabs represent, and whose inroads have brought desolation to the whole district. West of Shikurah, the country, though flat, was lovely; trees grew as if planted by a landscape gardener, and green turf reached to the banks of the Ngombe, a tributary of the Malagarazi, as wide as the Thames at Abingdon. Two days after leaving Kwihara the country gradually became more elevated, outcrops of granite, almost precipitous, and brawling torrents being met with. These unite to form the Mtumbo, a tributary of the Sindé. On the 22nd January the road led over a country covered with sheets and blocks of granite or gneiss, but well wooded and fertile; and after crossing some small rivers, the party encamped near the village of Ma'n Como, the chief of Uvenda, 3573 feet above the sea, past which the march was through a mountainous country affording splendid views. All this district is depopulated by the slave trade. On the 2nd February they crossed the Sindé by a natural grass bridge, half a mile long (the river itself being only 100 yards wide), beneath which hippopotami pass from end to end. The hill-country ends abruptly on the right bank of this river, and on the other side is the well-cultivated plain inhabited by the Wavinza.

Continuing the march to the banks of the Malagarazi, Lieut. Cameron reached Ugaga on the 7th February, thus, for the first time, coming on the route traversed by Burton and Speke in 1858. He crossed the river with his party on the 10th, the operation taking five hours, owing to the primitive nature of the canoes, although the stream was but 30 yards wide; and on the 13th entered the Ukaranga country, the villages of which are principally supported by the manufacture of the salt abounding in the black soil. After crossing the Rusugi and the Ruguva, the land road to Ujiji was found to be impracticable on account of the rains, and the party made for the shores of Lake Tanganyika, embarking on the 21st at Ukaranga in some fine large boats, and being hospitably received at Ujiji by the Waswahili and Wamrima inhabitants, traders and settlers of Arab extraction from the coast.

On the Commercial, Industrial, and Natural Resources of Peru. By T. J. HUTCHINSON, *F.R.G.S., F.R.S.L., M.A.I., late H.B.M. Consul for Callao.*

The author commented on our earliest knowledge of the history of Peru, observing that the country, even in early times, was as famous for its commerce and industry as for its precious metals. He considered the modern Peruvians to be the most industrious inhabitants of South America, as evidenced by their cultivation of cotton and sugar-cane, and dated the establishment of their commercial status from the Pacific Steam Navigation Company's inauguration in 1840. The condition of native manufactures, joined to that of agriculturists, seemed to point unerringly to success, in a commercial point of view, for a nation as it were instinctively industrious. The author then proceeded to a notice of the enormous amount of mineral wealth in the Andes, now about to be opened to the world by means of railways. Hitherto these rocky mountain-masses had rendered intercommunication impracticable, from the difficulty of transport across their almost impassable barriers. Foreign Office Reports were quoted, as furnished through the Admiralty from Rear-Admiral Cochrane, the present Commander-in-Chief in the Pacific. Recent findings of guano show an approximate amount of 9,294,500 tons, and exports of nitrates from Iquique have increased cent. per cent. in less than three years. In the author's opinion, Peru seems likely to reach the position before many years of being one of the first South-American Republics, as regards commercial prosperity. Drawings of various cuttings and tunnellings of the railways (some of which are now finished by the contractor, Mr. Henry Meiggs) accompanied this paper.

Travels beyond three Seas, by Athanasius Nikitin, Merchant of Tver, 1466–1472. *Compiled from Russian documents by* T. SRESNEFFSKY, *of the Imperial Academy of Arts and Sciences of St. Petersburg, and rendered into English by* E. DELMAR MORGAN, *F.R.G.S.*

Much fresh explanatory matter is here added to Nikitin's memoirs. They were first discovered by Karansin, who paid a high tribute to their importance in his 'History of Russia,' and have been critically reviewed in the Transactions of the Imperial Academy of Arts and Sciences by M. Sresneffsky, and translated by Mr. Major in one of the publications of the Hakluyt Society.

The 15th century, remarkable in the annals of Western Europe for a special desire to become acquainted and establish relations with the distant East, is not without its reminiscences to Russians, whose ancestors took their part in the progress of the times and the march of events, as far as circumstances would allow. The development of the kingdom of Muscovy, following the overthrow of the Tartar power during the reign of Ivan III., opened out new countries to the enterprise of Russian merchants; and, towards the close of the 14th and beginning of the 15th centuries, they traded with India, Persia, and Central Asia. Commercial intercourse was succeeded by closer political relations, and we read of interchanges of envoys between the Grand Dukes of Muscovy and the rulers of Transcaucasia and Persia. It was on the occasion of the departure of one of these embassies from Russia that Athanasius Nikitin, a merchant of Tver, started for the East. Taking with him his merchandize in two sailing-ships, he descended the Volga to Astrakan, where he was attacked by Tartars and lost all his goods; but, escaping in another vessel, after experiencing a violent storm in the Caspian Sea, he landed safely at Derbend. Here the travellers were in the dominions of the Shirvan Shah of Shamakha, who received them kindly, but refused to accede to their request to be sent home to Russia. After wandering about Daghestan for some time, Nikitin at length set sail for Persia from Baku in 1466 or 1467, and landed at Balfrush on the coast of Mazanderan. Thence he crossed Persia, visiting the most important towns and commercial centres, and arrived at Ormuz on the Persian Gulf. Three years later, on his return journey through Persia, he visited the "horde" of Uzum Hassan, of the Turkoman tribe of Ak-koinlu (white sheep), whose empire extended over the whole of Persia and a great part of Asia Minor,

and at one time threatened to shake the power of the Turks. Nikitin described the unsettled state of the country, owing to the ambitious designs of Uzum Hassan and the revolts and rivalry of his sons and vassals; and his remarks are the more valuable as they entirely confirm the records of the chroniclers. Sailing from Ormuz the week after Easter 1469, Nikitin approached, for the first time, the shores of India at the Peninsula of Gujerat; he touched at Din and Cambay, continuing his voyage to Chewul, where he landed and crossed the Ghaut Mountains, entering the Deccan and visiting the towns of Junir and Kulburga on his way to Beder, where he stayed for some time. Beder has now lost all its importance, but in those times it was the capital of a powerful Mahometan state and a great emporium for trade.

Our traveller visited the fair at Aliand (Allund), instituted in memory of Shah Alla ad Deen Hildji (1297–1347), who made himself notorious by his terrible march through the peninsula with 300,000 cavalry and 2700 elephants, devastating the country. Nikitin also accompanied the Indians to their sacred city of Parvat,—not Ellord, as Karansin and others believed, but most probably Parvattum or Perevattum pagoda on the right bank of the Kistna (16° 12'), south of Hyderabad, described by Hamilton as the site of one of the Buddhist shrines, marked to this day by some beautiful remains. In Nikitin's time this shrine was visited by pilgrims from all parts of India. It contained, among other objects of Hindoo worship, twelve temples covered with sculptures, illustrating the miracles of Buddha; a statue of that god, resembling that of the Emperor Justinian at Tsargrad or Byzantium; a black ox of stone covered with gilding, &c. Among the other places of interest described were Bidjnaghur, the capital of the great Indian kingdom; Rachiur, famed for its diamond mines; and Kulur (Culoor), a great industrial centre.

After the personal narrative of his journey, Nikitin records his observations on the country and its products; the people, their morals, customs, and religion; the government, the army, &c.: and some of these remarks are the more valuable as they are not to be found in the writings of any of his contemporaries.

It may be observed that in his time there were two principal kingdoms in India, the capitals of which were the Indian Chiumidar-Bidjnaghur and the Mahometan Khorassan-Beder. Of the former he communicates little, except that its Prince Kadam was very powerful and had a large army; but of the latter he notes that the ruling classes were all Mahometans of Khorassan—a proud race of conquerors, riding in armour, their Indian subjects poor, ill-fed, nearly naked, swift runners, with shield in one hand, bow and arrows in the other. The Sultan's army numbered 300,000 men, besides elephants and the contingents of his great lords or feudatories. The description seems almost fabulous of the splendour of the Sultan's Court, of the grand ceremonial processions on the Mahometan festivals, and of the wars and military exploits of the great Lord Meliktuchar attached to the suite of the young Sultan.

After three years' stay in India, Nikitin departed from Dapul, then a prosperous sea-port, on a "tava" or merchant vessel bound for the Persian Gulf. After being wrecked and falling into the hands of robbers, he reached Muscat, whence a few days' sail landed him at Ormuz. He then travelled through Persia to Trebizonde; and, after crossing the "Stamboul daria" (or Black Sea) to Balaclava, he could offer up his thanks with a grateful heart, exclaiming, "Thank God, I have crossed three seas."

By what route Nikitin returned to Holy Russia is uncertain; but, as he died at Smolensk before reaching his native Tver, it may be inferred that his road lay through the territory of the Khan of the Crimea and the Prince of Lithuania.

The record of his travels entitles him, in Mr. Morgan's opinion, not only to claim rank as a distinguished Russian of the 15th century, but as not unworthy to be named after Di Conti and Vasco de Gama.

On the Survey of Palestine. *By* Lieut. R. CONDER, *R.E.*

This survey is confined to Western Palestine, containing about 6600 square miles, which is bounded by the Jordan and the sea, and extends from Dan to Beer-

sheba. It is divided into five geographical districts—two on the south, comprising the hill-country of Judæa and the plain of Sharon; the third, containing the plain of Esdraelon and its boundary chains; the fourth, the hill-country of Galilee; the fifth, the Jordan valley. The country of the Beni S'ab or Shephalah, west of Nablus, was unknown until visited in this survey. The author described the commencement of the work (one-inch scale) in October 1871, and the share taken in it by Mr. C. F. Tyrwhitt-Drake, who died on the 23rd June last. The map was prepared on Sir H. James's system of tangential projection, in sheets containing 30′ of longitude and 20′ of latitude. Six of the proposed twelve are complete, and three are in England. The first base was connected with the trigonometrical point at Jaffa, the second being established at Esdraelon; this was $4\frac{1}{2}$ miles long, and the difference between its measured and calculated lengths gave an error of only ·03 per cent. The average length of the triangles side was about fifteen miles, but never greater than ten in the Judæan hills; and every possible check appears to have been employed in all cases with an encouragingly minute amount of error. The rate of work rose from 60 square miles per month to about 180 in October 1873, and then, with an extra man, gave a steady average of 280. All is done on horseback, and the method is most fitted for military reconnaissance. The heights are obtained by Abney's clinometer, sketches of hill-tops, aneroid observations, thermometrical readings, &c.; and astronomical bearings are constantly obtained as rough checks. As to names of places, the author observes that the original Hebrew names are still to be found under slightly modified forms of the Arabic. The collection and correction of these, tending to elucidate geographical passages in Scripture, were carefully attended to. The number obtained was very great (seven or eight times more than in any previous map), averaging two per square mile. Seventy special plans of antiquities, not before satisfactorily explored, are here mentioned; and seven churches and two sites of towns are stated to have been before entirely unknown. The antiquity of ruins in Palestine has been much exaggerated, many supposed to be Jewish or Phœnician turning out to be Crusading or Saracenic. The identifications of the altar 'Ad, the site of Ænon, Zaretan, Gilgal, Scopus, Oreb, Zeeb, Samson's tomb, Archelais, Ecbatana, Sozuza, and other places mentioned in Scripture were made during the survey, and various other points and discoveries of archæological interest are discussed. As to climate, there is an entire absence of ozone during the east wind; the mirage is not dependent on heat only, but requires also moisture; and the rise and fall of the barometer has no reference to storms in the Jordan valley, though a safe guide in the hills. The Forest of Sharon has been found extending for miles on the northern part of the plain; and altogether the seasons, rainfall, and natural vegetation of modern Palestine resemble very closely those of Biblical times. The vine, now unknown, was once much cultivated. A volcanic centre has been discovered in the plain of Esdraelon, and a tertiary volcanic lake south-west of Carmel.

Notes on a recent Journey East of the Jordan. *By the* Rev. J. L. Porter, *D.D., LL.D.*

Eastern Palestine is divided from Western by the valley of the Jordan, which extends from the base of Hermon to the borders of Edom, a distance of 150 miles. For about 130 miles its surface is below the level of the sea, its depression at one place being 1312 feet. This great chain gives the country eastward its most striking physical feature. Viewed from the west, it appears an unbroken mountain-chain; but when ascended a tableland is seen to stretch from its summit into Arabia. The central erection rises into wooded heights, with an average elevation above the plateau of 600 feet: this is Mount Gilead; while the southern tableland is Moab, and the northern Bashan. The western side of the country is deeply furrowed by ravines, three of which are historically important:—1, the Arnon, which separated the Moabites from the Amorites; 2, the Jabbok, which was the northern border of the Ammonites; and 3, the Hieromax or Jarmuk, the boundary between Bashan and Gilead. The country was the scene of some of the most remarkable events in early Bible history, such as the raid of the Eastern

Kings upon Sodom and the conquests of Israel under Moses. Questions of importance arise in connexion with those events. Are there any traces, monumental or traditional, of the aboriginal races? or can the line of conquest be followed? The ancient inhabitants had some very marked characteristics; they were to a large extent migratory; they were subject to wild outbursts of passion; they were celebrated for unbounded hospitality; they had a peculiar costume and a peculiar accent. It is therefore important to inquire whether there be any thing in the physical features, natural resources, or geographical position of the country that would account for these characteristics, or whether any of them still exist.

The author proposed to show the conclusions he had arrived at upon these and other points, while giving a sketch of his recent journey. He left Jerusalem on 13th April, but was unable to cross the Jordan at Jericho, because, as stated by Joshua, the river at that season "overfloweth all his banks." He travelled up the plain to Damich, and crossed a ferry beside the ruins of the Roman bridge, over which ran the ancient road from Neapolis to Geraxa and Philadelphia. He showed that the dress of the people beyond the river is different from that of the Western tribes, and of a more primeval type; their pronunciation of certain words is also different. He ascended Jebel Osha, the highest peak of the Gilead range, and identified it with Mizpah, where Jephthah assembled the Transjordanic tribes. He also showed that Es-Saet is the Ramoth Gilead of the Bible. He travelled south to Arak-el-Emîr, and described the remarkable excavations and classic ruins of the palace of Hyrcanus. Thence he went to Heshbon, and pointed out how it commanded the passes from the plateau of Moab to the Jordan valley, thus rendering it necessary for Moses to ask permission of Sihon to pass through his territory. The western brow of the plateau is deeply furrowed, and the projecting peaks near Heshbon formed those "heights of Pisgah" which looked "towards Jeshimon," *i. e.* "the desert" beyond the Dead Sea. He described the ruins of Nebo, showing that it was a town which gave its name in ancient, as it does in modern, times to some peaks around it. One of these peaks bears a name which is probably a corruption of Pisgah, and the view from it is similar to that described in the account of Moses's death. The author went to Rabbath Ammon over a table-land rich in pastures and dotted with ruined towns. He urged the importance of excavations at Rabbah as likely to be productive of interesting archæological discoveries. He travelled thence to Gerasa, through the semicircular region of mountains skirted by the ravine of the Jabbok, and illustrating the statements in the Bible regarding the strength of the borders of the Ammonites. He suggested Neby Hûd, a noted sanctuary between the ford of the Jabbok and Gerasa, as the probable scene of Laban's covenant with Jacob, and proposed to identify Gerasa with the long lost Mahanaim. From Gerasa he made an adventurous journey through an unknown region to the plain of Haurân, following the line of an ancient road; and he gave reasons for believing that this was the route by which Abraham and Jacob entered Palestine, and by which Moses invaded Bashan. He denied the identity of Dera with the Edrei of Og, maintaining it to be the Adraha of the Peutinger Tables, and followed the Roman road there laid down to Bozra. Thence he went north to Jebel Haurân, visiting its old cities, and describing their architecture. He argued that some of the private houses in those cities are much older than the Greek temples beside them, giving measurements of a few of the massive stone doors. Here were two colossal heads of Astarte, with the crescent on the forehead which give that deity the name found in Genesis, Ashteroth-Karnaim. The ruined temples and palaces of Sîah contain inscriptions bearing the names of Herod the Great and Agrippa; and there is one in Nabathean characters of a very remarkable type, apparently recording the erection of a statue to a certain Malkath about 30 B.C. From Kenath he crossed the plain of Bashan to Mezarib, and then, turning southward, passed over the northern ridge of Jebel Ajlûn, visiting several cities of Decapolis, and finally crossing the Jordan valley to Bethshean. In conclusion, the author strongly urged the importance of a regular survey of the whole country, as calculated to illustrate Biblical geography and archæology.

The Yarkund Mission. Communicated by Colonel BIDDULPH.

The advanced party of the expedition, of which Colonel Biddulph's brother, Captain Biddulph, was one of the chiefs, started from the station of Murree (Punjaub), on 15th July, 1873. It consisted of 80 men and 100 animals, and included Dr. Stoliczka, the celebrated Indian naturalist (who eventually succumbed to the inclemency of the climate). They reached Leh *viâ* Srinuggur on 27th August, much tried by heavy rain, at times washing the road away, and by the temperature, which varied from 31° to 140° in a single day. After a fortnight's halt they again set out by the Changchenmo route, passing the last human habitation at Tanksee (on 16th September), 13,000 feet above the sea, an elevation continuing to Shahdula, a five weeks' journey. The temperature continued variable, and at times very low—at the Sakti Pass (15,000 feet) 118° at noon and 5° at night. After heavy snow, they reached the Pangkong Lake (142 feet deep) on 20th September, and separated on the 26th, Captain Biddulph wishing to find a short cut to Kiziljilga. After crossing very easily on foot a pass 19,200 feet high, a grassless track of low and rounded hills, like Brighton Downs, was reached, the gradient of descent from which was only 600 feet in ten miles. The Lingzi-Thung plains (17,000 feet) took two days to cross, traversed by snow-storms and most bitter winds, the thermometer being twice at zero within half an hour of sunset. Here, in spite of the precautions taken in sending on supplies and establishing depôts, twice they encamped without fuel and once without water.

Kiziljilga was reached on 1st October, and, although snow fell daily and ink froze in the pen, was found comparatively warm. The party here again united; but the severe cold utterly demoralized the native servants and caused much illness, a fierce cutting wind blowing daily from noon to dusk, so that little exploring could be done. Starting on 7th October, they followed the River Karakash, visiting jade-mines deserted by the Chinese, and joining the main body with Mr. Forsyth, who had crossed the Kara Korum without difficulty at Shahdula; leaving which place on the 21st, after crossing the Grim Pass (the most difficult they passed, though but 16,500 feet high), they once more met with vegetation, and, after crossing the desert of Gobi (four days) and camping in an oasis, arrived at Yarkund on 8th November. Here horses (like big Welsh ponies), cattle, sumptuous dinners, and fruit abounded, and daily marches of thirty miles were easily made. The Yarkundees are quiet and go unarmed. They will doubtless rise in the scale of nations, as they intermarry with the upper class Andijanees, a much superior race. There are no antiquities in this very ancient but entirely brick-built city. Its chief is the Dad Kwah, the second man in the kingdom.

Leaving Yarkund on 28th November, the mission reached Kashgar in five marches of twenty-six miles average, and stopping two days at Yanga Shahr, where there is a strong fort. At Kashgar new and most comfortable quarters were provided, and the officers were allowed to go about the city at pleasure and shoot game in the neighbourhood. A treaty of commerce with the Átálik Ghazi (now Ameer) was negotiated by Mr. Forsyth, and finally returned ratified in charge of Mr. Shaw as British envoy. Permission being given to travel, Colonel Gordon and party went northwards ($8\frac{1}{2}°$ below zero in tents, 26° below zero outside), and Captain Biddulph eastwards. Letters were sent regularly to India during the winter, but were delayed by the comparatively low Zoji-la Pass (11,500 feet), sometimes closed for weeks by snow, which always lies lightly on the higher Kara Korum.

On 17th March the mission left Kashgar and separated at Yangi Hissar, Mr. Forsyth returning to India and Captain Biddulph starting with Colonel Gordon's party (42 men, 65 horses) for Sir-i-kol on the 21st. On the 30th, after crossing three snow-passes, they reached the important strategic position of Tashkurgan (11,000 feet) on the edge of the Pamir Steppe, commanding the high road to India by Chitral, and where various important routes converge. It is the last place on that side in the possession of the Átálik, whose rule appears most just and equitable, and who has increased the welfare of the country in less than ten years to a degree before unheard of in Central Asia.

After much snow, traversing a road 13,000 feet high, and crossing four passes, they reached Kila Panja, on the Oxus, in Wakhan, on 13th April, *viâ* Aktash and

the little Pamir, by the lake Barkut Yassin. The Pamir was crossed by twenty-five mile marches through deep snow-drifts, firewood having to be carried for seven marches and grain the whole way. Its drainage is all to the west, the Kizzilyart plain being the true watershed. There are *two* lakes called Kara-kull, one draining east, the other west, the apparent discrepancies in the accounts of former travellers being thereby explained. Wakhan itself is very poor and thinly inhabited.

The party, not receiving permission from Shere Ali to proceed *viâ* Cabul, left Kila Panja on 26th April, Colonel Gordon returning by the Great Pamir and Captain Biddulph by the Little Pamir, diverging from the original route at Surhud with the view of visiting the Buroghil and Darkot passes, never yet seen by a European.

Notes on some Roads in Northern Persia and on the Russio-Persian Frontier. By Lieut. Gill, *R.E.*

Lieut. Gill accompanied Colonel Baker in a tour through Northern Persia in 1873, during which he made a rough survey of the country seen, determined the latitude of places and their altitude by aneroid or hypsometers. The mountains to the south of Teheran rise to an altitude of 15,000 feet, and the roads through them wind along fearful precipices and are practicable only during summer, after the melting of the snows. Gulhek is one of the most charming villages at the foot of these mountains. It absolutely belongs to the British Government, and its inhabitants are exempt from paying taxes. All the valleys on the southern slope of the great mountain-range which separates the tableland of Teheran from the plains of the Caspian abound in water and vegetation; small villages occur at intervals of two or three miles, and in their fields the streams, having their rise in the hills, are absorbed by irrigation before they reach the desert plain. The upper portions of the valleys afford pasturage to sheep and goats, and in the most inaccessible recesses the mouflon and ibex are met with. Coal of fair quality is found at Shunshak, but owing to the cost of transport it fetches as much as £3 a ton at Teheran. Immediately on crossing the water-parting towards the Caspian the nature of the country changes, and the valley of Lar contrasts by its dreariness with the valleys to the south. Its stream abounds in excellent trout; and at Ask, well known for its hot sulphur-springs, cultivation is carried on extensively. The valley is hemmed in several times in succession by precipitous rocks, until it enters a wooded park-like country, extending to within five miles of Amol. A large portion of the Caspian plain consists of jungle, and cultivation is not so extensively carried on as might be expected. Amol, at the time of Lieut. Gill's visit, was almost deserted, the inhabitants having gone to the hills. The nature of the country remains the same as far as Bartrush; but thence, and as far as Ziaret, it is covered with extensive forests of magnificent planes, beeches, oaks, walnuts, and immense box trees, having trunks as thick as a man's wrist. The teak likewise grows in certain localities. Cultivation is carried on only at a few spots. Above Ziaret the forest ceases, and beyond a pass 4500 feet above the sea a fertile valley, thickly populated and affording pasture to sheep and cattle, is entered upon. The trees here grow in clumps, and beyond Atula they disappear altogether, and a barren plateau, seven or eight miles across and 7000 feet above the sea, is entered upon. This plateau forms the water-parting between the Caspian and the rivers flowing inland towards the desert. Lieut. Gill proceeded by a well-known road to Shahrud, Sebzawar, and Mushed, the latter, aside from its sanctity, offering no features of interest. Kilat is one of the most remarkable places in the world. It lies in a circular valley encompassed by precipitous hills, and accessible only through five narrow gorges not more than two or three yards wide. Water abounds; and as there is much space for cultivation, the inhabitants could hardly be starved out. On the road from Kilat to Idalik the mountains rise to a height of 10,000 feet, and from the top of the difficult pass the valley of Atrek may be seen. The Persian frontier province of Deregez is described as one of the most prosperous of Persia; and, though situated in the immediate vicinity of the Turkmen, it suffers nothing from their incursions. This prosperity is due entirely to the wise government of Elia Khan, whose family has held the post of governor for many years past, and

whose honesty contrasts stikingly with the corruption pervading every class of Persian society. Lieut. Gill reached the Atrek at Sison, and descended its valley Pishkala, below which it is in the hands of the Turkmen. The valley of the Atrek is about ten miles wide, and is bounded by mountains of considerable height. From Pishkala, Lieut. Gill crossed the wooded hills to the Samulkhan valley, and thence to the plain of Shushan. Near the village of Saughoss he enjoyed a few days sport, and then turned his footsteps to the East, passing Jajerm on the road to Teheran.

On the Russian Expedition to Khiva.
By J. A. MacGahan, *late Correspondent of the 'New York Herald.'*

The Russian campaign against Khiva was remarkable for the admirable manner in which the expeditionary force was supplied with every requisite for a march across a waste of sands. The operations of the topographical corps merit special attention. The Russians keep pace, in the survey of the country, with their advance in Central Asia, and every reconnoitring force, every embassy, is accompanied by competent surveyors. Struve's and Kaulbars's visits to Khiva and Kashgar are instances of this kind. The roads to Khiva had been explored by flying detachments long before the late expedition was undertaken, and the expeditionary force never moved until the ground in front had been reconnoitred by flying detachments and the capacity of the wells ascertained. The only part of the route not explored in this manner, owing to the presence of Khivan forces, was that between Adam Kurulgan and the Oxus, and this omission nearly led to a disaster. General Kaufmann fully appreciated the value of these explorations, though he does not seem to have treated the officers employed on this arduous service with the consideration they deserved. The trigonometrical survey of Russian Turkestan is proceeding rapidly, and the time when a map of the whole of Central Asia, based upon accurate data, can be prepared is not far distant. The extensive explorations of Russian travellers become but rarely known to the rest of Europe, for they are published in a dry matter-of-fact style, and not in the shape of readable books. The surveyors attached to the Khivan expeditions have probably determined by this time the old bed of the Oxus. In conclusion, the author describes the soil of Khiva as being exceedingly fertile, producing crops of wheat, barley, and rice, not to be surpassed elsewhere.

Reproduction of Maps and Plans in the Field.
By Captain Abney, *R.E., F.R.A.S., &c.*

The author pointed out the immense advantage that must accrue to military commanders by placing in every subordinate officer's hands a plan of the ground on which the campaign might take place. A large scale of map, at least 6 inches to a mile, was recommended, as on it every feature of the country might be shown. Two modes of securing this have been introduced into the service, reproducing by lithography sketch maps made by officers and men when executing a reconnaissance. A peculiar kind of ink is employed, invented by the author, which is capable of being transferred to stone or zinc from any paper. The advantages claimed for this are, that the ink is liquid like ordinary ink; that it is not greasy in the ordinary acceptation of the word as applied to lithography, and consequently there is no danger of finger-markings obliterating the drawing by their transfer to the stone or zinc; and finally that unprepared paper can be used for the drawings. The next point touched upon was the method of reproducing plans by photography, either to the same or larger scale. The process adopted for these was called papyrotypy. This differs from ordinary photo-lithography in rolling up a print from a negative in greasy ink direct on the paper, after immersing it in *cold* water. Those parts acted upon by light take the ink, as they do not absorb water, whilst those parts unacted upon by light, and which do absorb water, remain intact. The paper print thus obtained is really a transfer which will go down to stone or zinc. From that point the work is that of ordinary lithography. It was then pointed out that papyrotypy was capable of giving half-tone prints as in the

heliotype process, and was utilized for that purpose in the field. The field equipment for these processes consisted of a photographic, a lithographic, and printing waggon, all of which are attached to the telegraph troop of the Royal Engineers, each waggon being horsed by four horses. Enough material is carried for a four months' campaign for every purpose for which the respective waggons are adapted. A mountain equipment for each of these processes was described. It is capable of being carried on the backs of mules, and is therefore adapted for such campaigns as the Abyssinian and Bhootan.

On Reconnaissance of a new or partially known Country.
By Lieut. Warren, *R.E.*

This paper is practically an exhaustive instruction-book for military surveyors, consisting mostly of mechanical detail, and quite incapable of being abstracted with utility.

On Surveys in Ireland. Communicated by the Ordnance Department.

The circumstances connected with the Government surveys of confiscated lands in 1586, 1609, and 1652 are here succinctly narrated, the last (the "Down" survey) being given more in detail. After a sketch of the origin of the English Ordnance Survey, its extension in 1825 to Ireland (when the triangulation commenced on Divis Mount near Belfast) and subsequent operations are described, and the various uses to which the resulting maps may be put are recapitulated, the older surveys being shown to have been but portions of various oppressive plans, whilst the operations of the present scheme relieve all classes from unequal taxation, simplify the conveyance of land, and in various ways act equitably for the good both of individuals and the State.

Note on the International Congress of Geographical Sciences.
By Mons. Charles Maunoir, *Secretary of the French Geographical Society.*

After a precise account of the origin and proceedings of the first meeting of the Congress at Antwerp, from 14th to 22nd August, 1871, and of the successful steps taken by the Organization Committee of that meeting to induce the French Geographical Society to undertake the management of a second gathering at Paris, the author gave details of the composition and labours of the General Commission and its Subcommittee, resulting in the appointment of an Honorary Committee and a Committee of Congress, the latter divided into Scientific, Organizing, Exhibiting, Publishing, and Account sections, and the Scientific Section being subdivided into Mathematical, Hydrographical, Physical, Historical, Economical, and Instructional branches, with another for explorations and travels.

The points settled by the Committee of Congress were:—1, the establishment of a provisional Board of Inquiry, to which questions could be referred, each of the scientific groups being required to prepare a series of these; 2, the constitution of an Honorary Committee of all Nations (a full list of the members hitherto elected being given); 3, the procuring the countenance of the French Government and of the Parisian municipal authorities.

Subscriptions were fixed at 15 francs for each member, and a separate class for donors of 50 francs and upwards was instituted.

It was fixed that the Congress should open on 31st March, 1875, and last (at most) for ten days. Separate morning meetings were to be held in the various groups, and general afternoon sessions. The Exhibition will open simultaneously with the Congress, and close on 30th April, when prizes awarded by an international jury to exhibitors will be given. Transactions and Proceedings of the Congress will be published, with lists of subscribers and donors, and a copy of such publications, and a card of admission to the meetings and the Exhibition, will be given to each subscriber or donor.

ECONOMIC SCIENCE AND STATISTICS.

Address by the Right Hon. Lord O'Hagan, *President of the Section.*

Since I accepted the invitation of the Council of the British Association to meet you here, I have glanced through the Addresses of some of the gentlemen who have heretofore enjoyed a similar distinction, and I find, in most of them, an authoritative statement, that brevity is held a virtue in the Presidents of its Sections. I appreciate the reason of the rule: it has my full approval; and I shall endeavour to act upon it, so as to avoid delay of your discussions, or anticipation of their details, or prejudgment of any questions which may probably come before you.

I am glad to have the honour of presiding over such an assembly in a town to which I am attached, not merely as the place of my birth, but, far more, by life-long associations of interest, duty, and affection. I rejoice that it is again distinguished by the presence of so many men illustrious in every walk of science, who come to take counsel together, as to the conquests of human thought and the extension of the bounds of knowledge; and I may be permitted to say that Belfast, in its industrial eminence, its honourable traditions, and its intellectual progress, is not unworthy to receive them.

As to its varied industries, they may more fitly be considered by other Sections of the Association, in their connexion with those branches of science (such as Chemistry, Natural Philosophy, or Mechanics) with which they have more direct concern. But the Statistician and Economist, without trespassing on the province of any of those branches, has relations with them all—aiming to test the value of their results and make them practically conducive to the general well-being. Thus, when you note the wonderful progress of this community—increasing in population from 37,000 in 1851 to 174,000 in 1871, and possessing multitudes of palatial manufactories where, within my own memory, there was exactly one—you may be led, legitimately, to consider its causes, its consequences, and the means of its extension. You may find food for profitable speculation in examining the industrial efforts which continue that progress without pause or faltering; and, perhaps, amongst them not the least remarkable is that which has established great iron-foundries, winning for their work the highest honours in the industrial competitions which have occupied the capitals of Europe from time to time for a quarter of a century, and commanding orders from the most distant regions of the globe. Or you may examine, with equal interest, ship-building establishments which employ skilled artisans in thousands, send out scores of great vessels to traverse the Mediterranean and bridge over the Atlantic, and have cultivated the special manufacture of long iron-decked ocean-steamers, from the year 1861, when it was first begun, until they have produced the gigantic 'Britannic' and 'Germanic,' measured at 5000 tons (not surpassed, if they have been equalled, in any country), and exhibiting improvements which are largely imitated in all ocean-going ships throughout the world. But apart from its general industries, Belfast has peculiar claims on the good will of this branch of the Association.

It is nearly a quarter of a century since, at a former Meeting of this Association in this town, the place which I now fill was more fitly occupied by the late Archbishop Whately, whose services to Economic Science, as well in his own masterly publications as in the liberal energy with which he encouraged the study of it in Ireland, I need not eulogize before this assembly. On that occasion there were not wanting able and instructed men to show that its principles had already found acceptance here. Such men had been already active in the prosecution of those special inquiries which in this section it will be our business to pursue. In distant days, when Belfast was poor in material wealth and very limited in population, they had formed a speculative and literary society which did excellent work. They had, also, societies for the culture of natural science, and others which were useful in training young people for the encounters of public and professional life. And these, with great schools, which were the creation of the spirit and enterprise of private persons, tended to the remarkable advancement of individuals, and assisted in laying the foundations of that great prosperity, the

unaided growth of self-reliance and self-assertion, which has so distinguished this community amongst the cities of the empire.

It was not strange that, with such antecedents, Belfast should have early moved in the new path of statistical inquiry; and accordingly, long before the meeting to which I have alluded, it had established a Social Inquiry Society for the consideration of "Statistics, Political Economy, and Jurisprudence," which, in some particulars, remarkably anticipated the Social Science Association, and was, whilst it existed, very useful and efficient. And thus it came to pass that not the least distinguished of those who, in 1852, discussed the subjects peculiar to this section, in able papers, were inhabitants of Belfast, some still living and some departed, who well maintained the intellectual reputation of their town. Subsequently, the Social Inquiry Society merged in the larger combination represented by the Statistical and Social Inquiry Society of Ireland, which has laboured, and continues to labour, in the metropolis, with great and increasing success. It has dealt, in its published transactions, with almost every important economic question of the time, and has acted beneficially, by suggestion and argument, on the Irish legislation of later days.

It has operated, also, in spreading economic knowledge through the organization of the Barrington Lectureships on Political Economy, which were founded by the munificence of a citizen of Dublin, and through which competent teachers afford the opportunity of instruction in the principles of the Science to the various towns of Ireland. But although the capital of the Ulster Province has thus allowed its local society to be absorbed in one which is national, the spirit which originated both continues to prevail in Belfast; and it will gratify the members of this section to learn that, in the month of January last, a committee was formed to establish classes for the systematic teaching of Political Economy chiefly to young men engaged in mercantile pursuits. That committee is composed of the Chief Magistrate of the town (to whose intelligence, energy, and affluent liberality, I am not surprised to learn, the British Association is largely indebted), many of its leading merchants and professional men, and several eminent professors of the Queen's College. They were fortunate in obtaining the services of a highly informed economist; and the experiment has, so far, proved very satisfactory. The number of students on the roll has been 55,—3 of them alumni of the Queen's College, 7 apprentices of solicitors, and 45 engaged in commercial business. The average of attendance on the classes has been from 40 to 50. The committee may well be congratulated on the result of their novel and excellent effort, and the probable influence, in other communities, of the example they have given. Already it has been imitated in Dublin; a class of young mercantile men has been formed in the metropolis for a similar purpose; and there is no reason why others should not compete with it there and in the provincial towns.

In connexion with this matter, I may mention that very recently a considerable portion of the Barrington Fund has been devoted to the instruction in Political Economy of schoolmasters, who are examined in its principles under the direction of the Barrington Lecture Committee of the Statistical Society; and at an examination held on the 12th of May last, 13 of them obtained distinctions and certificates. The importance of such a movement I need not dwell upon. It was anticipated by Archbishop Whately in the preparation of his 'Easy Lessons on Money Matters' and other books; and I find that the Labour and Capital Committee of the Social Science Association have endeavoured to induce the Educational Committee of the Privy Council in England to promote the teaching of economics in schools under its inspection, and have urged the importance of such teaching on the Lord President, for reasons which, in the painful circumstances existing around us, may not unprofitably be repeated here. They declared their strong conviction "that the hostility between Labour and Capital, arising from an erroneous belief that the interests of workpeople and their employers, and of tenants and landlords, are opposed to each other—a belief leading, in manufactures, to attempts to oppose harrowing restrictions regarding rates of wages, hours of labour, piece work, number of apprentices, and the use of machinery; and, in agriculture, to attempts to dictate the amount of work to be exacted and the selection of tenants; and leading, in its further stages, to strikes, lock-outs, rattenings, and threats of personal violence, and ultimately, in many cases, to

murder itself—might have been mitigated, and in great measure prevented, had the people of this country in their youth, and before the mind could be warped, been instructed in the elements of Economic Science." And on this, and on other grounds, they urged that no more time should be lost in taking measures for gradually introducing this knowledge, as a regular branch of education, into all schools to which the State gives pecuniary aid. Their demand was not fully conceded; but a beginning has been made in England as in Ireland, and the study has been introduced in some large schools under efficient inspectors. Individuals have made the same experiment in London and Glasgow (eminently Mr. Ellis and Mr. M'Clelland), and with a success demonstrating the feasibility of imparting economic knowledge to young people, and making it full of attractive interest to them. We must all sincerely trust that the same success may attend the effort which has been so well begun in Ireland.

I do not think I need apologize for these references to the connexion between economic and statistical science and the intellectual traditions of Belfast; for, whilst they prove that I am not unwarranted in asserting its worthiness to receive this great Association, they must gratify specially those whom I address, as indicating a healthy interest in the prosecution of that science and a continuous effort to assist its progress here.

It is impossible to exaggerate the importance of such progress to the highest interests of every class of our society. The branch of knowledge with which we have to deal must have had an existence coeval with all advanced civilization, although its name is new. It could never have been ignored by the historian, who properly marshalled facts and drew inferences as to the characters and actions of individuals and the causes of the rise and fall of nations. It was necessarily cultivated by investigators of the working of commercial communities, and the influences which affect their prosperity or decay. It was implicitly recognized by all careful and conscientious statesmanship, in dwelling on the events and circumstances which might require the maintenance of institutions or warrant their abolition or reform. Those who fulfilled such functions were, consciously or unconsciously, statisticians and economists, although the recognition of statistics and economy, as distinct domains of human knowledge, and the cultivation of them, with exclusive attention, are comparatively of recent origin in the world of thought.

It is not, perhaps, matter of surprise that such new-comers have not always met a cordial reception—that the masters of exact science have sometimes looked askance on their looser and more speculative methods, and disputed their right to rank at all with the older scientific sisterhood. But the controversy was never of much practical account; and it has well-nigh ended.

The statistician and economist do not demonstrate; do not claim for their propositions the certainty of mathematics; are too much engaged with the shifting conditions of human existence and the infinitely varied shades of human thought and feeling to pronounce, with rigid dogmatism, as to the course to be adopted in all the varying circumstances which concern the wealth of nations and the social interests of mankind.

But, nevertheless, they are entitled to call their labours scientific, if science be needed to deal with subjects and educe results of the last importance to our race, and to accomplish this by drawing, from facts rightly ascertained, lucidly classified, and profoundly considered, conclusions of permanent truth and wide application for the government of human conduct and the increase of human happiness.

The reign of Law is not bounded by the physical universe. Its vigilant power is not exhausted when the planets have been kept in their courses and the earth is made bountiful for the maintenance of man. As the material creation assuredly did not owe its harmony and beauty to a fortuitous concourse of atoms, so the humanity, to whose needs it has such a marvellous adaptation, has not been left to be the sport of chance, stumbling through the ages in blind disorder and hopeless desertion by the Infinite Power which called it into being. There is a moral government which "shapes our ends," pervading the apparent chaos of motive and action, and making the liberty which belongs to us, as individuals, subordinate itself, with a felicity as admirable as it is incomprehensible, to the promotion of the universal good. Three millions of free and responsible beings constitute the population of London, each having his own idiosyncracy and power to

act in independent isolation, but all overruled and subdued by an overmastering, although an unacknowledged influence, to the working out of a common system by which, whilst they prosecute, for their respective interests, their separate objects and pursuits, they supply one another with all things useful for their existence and enjoyment.

This is surely the greatest of marvels; and it is achieved, as no human power could achieve it by any governmental force or police strategy, because there is a Law which dominates the movements of society and moulds the earthly destinies of men. And, surely, the inquiries which are bent to the comprehension of that Law, and strive to ascertain the principles on which it acts, from earnest observation, laborious record, and just appreciation of the facts which, more or less clearly, disclose its systematic operation in the various departments of human effort, are vital to our well-being and progress in the world. They are fruitful in precise and enduring results. They have already, in many points, revolutionized the opinions of communities and shaped the policy of cabinets, and they have furnished canons of public conduct which have had an ever-widening acceptance wherever civilization has made its way.

Statistical inquiry is, therefore, scientific inquiry, and scientific inquiry of the highest value; and its successful prosecution is important to every class of men, from the statesman and the legislator to the humblest operative. It has relations with all matters of real human interest. It touches the reciprocal rights of classes, the claims of capital and labour, the advancement of education, the repression of crime, the relief of distress, the prevention of disease, the improvement of agriculture, the extension of commerce, and all the various cognate questions which affect our social and industrial state.

All men may profit by an acquaintance with a department of knowledge which concerns all alike—the high and the low, the wealthy and the poor. If there be ascertainable laws by which the relative rights and responsibilities of human beings are regulated, and by the evasion or defiance of which they must suffer inevitable injury, it is plainly important that some knowledge of such laws by all men should promote the equitable and reasonable enforcement of those rights and responsibilities.

There is, at present, a sad encounter of classes in this great town, which has paralyzed its most important industry. As to the origin of the dispute or the conflicting views of the parties to it, I do not presume to offer an opinion. But I may say for myself, and I am sure for those whose pleasant meeting here has been clouded by that grievous calamity, that we lament its occurrence, and trust it will find a speedy ending, for the avoidance not merely of privation on the one side and embarrassment on the other, but of evil consequences which may bring permanent mischief to every order of the community, and damage vitally the great commercial position of Belfast. I refer to the sad subject only to indicate how important it might have been if the educational effort on which I have already spoken had so far advanced as to spread abroad a knowledge of the issue of like encounters in other places and at other times, and of the teaching to be derived in this, as in most things else, from that old experience which

> "Doth attain
> To something of prophetic strain!"

But the statesman and the legislator need the knowledge which is accumulated by statistics even more than the mass of men. To legislate aright, to guard a nation safely through calm and stormy times, to take advantage of opportunities of safe and wise reform, and avoid alike the evils of obstinate adherence to abuse and reckless innovation, a member of Parliament or a minister holding political power should qualify himself by familiarity with that science of which a most eminent professor of it (Dr. Farr) has said:—"Statistics underlies politics. It is in fact, in its essence, the Science of Politics without party colouring." And yet there are many members and some ministers who, from time to time, undertake the discharge of their high functions without any such preparation as is deemed essential in the aspirants to any ordinary profession—of which, in their case, some little statistical and economic knowledge might well form a necessary part. Political action should not be altogether empirical: and scientific instruction, specially aimed to qualify for the undertaking of it, might be usefully supplied by our higher

schools and universities, in far larger proportion than they now afford it; for they would so supply new faculties of perception and persuasion to the political aspirant, whom they might train to marshal facts for the elucidation of economic questions, and apply established principles in the novel emergencies which perpetually test the quality of statesmanship; and so, promoting an attempt to found legislation on a scientific basis, or, at least, to have it conducted with informed and forethoughtful intelligence, they might take away, in some degree, the reproach of the famous Chancellor—

"Quam parvulâ sapientiâ regitur mundus!"

There are, no doubt, subjects on which the law-maker may decide promptly and on the first impression; but on most of those which are really important and permanently affect the general interest, he should seek the help which the statistician can afford by casting light from the past on the dim pathways of the future, if he would avoid perfunctory and haphazard legislation, issuing often in serious mischief, and necessitating attempts at unsatisfactory amendment, which he need never have essayed if he had allowed that light to lead him to an appreciation of the difficulties in his way and the means to master them.

Still further, the statistical method may be employed beyond the bounds of municipal arrangements, and made to operate for the benefit of that great community of nations, ever more closely approximated to each other by the practical annihilation of space and time which has been accomplished by the railroad and the steamship. It may assist the jurist in dealing with the vexed questions of international law and preparing the way for that progressive agreement as to the reciprocal claims and duties of civilized states; and this, though it cannot, perhaps, whilst man is man subdue the turbulence of ambition or end the crimes and calamities of war, may promote, at least, an approach to that "federation of the world," which may be delayed or forbidden by human pride and passion, but is dictated by the highest interests of mankind.

But, further still, there are collateral advantages which statistical inquiry affords, in bringing together, to such a meeting as this, men of science and men of the world (the professor, the actuary, and the politician), who find the occasion of union and mutual benefit in a pursuit which exercises at once the student's capacities of intelligent research and logical deduction, and aids, as I have shown, to a happy issue the best efforts of those who move in the busiest and the noblest spheres of active citizenship.

And, even more widely, it promotes the diffusion of intelligence and the unity of intellectual effort throughout the earth, as in the case of the International Statistical Congress, which was originated at the London Exhibition of 1851, and has assembled successively in Brussels, in Paris, in Vienna, in London, in Florence, at the Hague, and, lastly, in St. Petersburgh. At those meetings various countries have been represented by delegates from their Governments and by men of science, with the object of discovering the best modes of statistical inquiry, of ascertaining the facts capable of numerical expression which can be collected in all civilized communities, and of establishing a world-wide uniformity of statement, tabulation, and publication of those facts, giving a more exact and scientific character to results, and making them more available for universal usefulness. At the last Session, the eighth of the series, in St. Petersburgh (of which I should be glad, if I had time, to give some account from a Report of Mr. Hammick, one of the foremost of living statisticians, with which I have been favoured), notwithstanding the distance from which they came, and the dangers they encountered from cholera and otherwise, 128 foreign members attended from almost every country in Europe, from the United States of America, from Brazil, Egypt, and Japan. There were 360 Russian members, including the first scientific men and University professors from all parts of the empire. The Grand Duke Constantine presided and opened the proceedings in a forcible address. The Emperor gave his best assistance in every way, and the meeting was most harmonious and successful. I cannot attempt even to indicate the nature and the fruits of its important labours; and I refer to it only that I may illustrate, by a late and conspicuous example, the mode in which the prosecution of statistical studies may tend to promote the good understanding of Governments, to dissipate the evil prejudices which have so often held nations in unnatural and absurd antagonism, to diffuse the highest

intelligence of its most instructed members amongst the whole family of states, and bind them together by an identity of mental action and an equal participation of discoveries and suggestions abounding in advantage to them all.

I fear I have already overpassed the limits which should have been prescribed by my undertaking to be brief, and I pursue no further the general considerations on which I have partially and imperfectly entered. But it seems to me that those who are charged with the duty which I have assumed may fairly be expected to make some allusion to matters within the sphere of their own special division of scientific knowledge, which may have peculiar relations with the localities in which they act. The opportunity of concentrating attention upon such matters may be judiciously and largely used by the authors of papers in the several sections; but a very brief allusion to some of them should be allowed to make the opening addresses "racy of the soil." I shall merely glance at two or three, which will be of interest as belonging to Ireland.

I believe that in no other department of statistical inquiry has such progress been made in these countries, within living memory, as in that which comprehends "Judicial Statistics"—dealing with crime, its motives, its causes, and the means of its repression, and with all the various questions of interest which arise in connexion with the administration of civil and criminal justice. In this department, men of high intelligence have long been labouring throughout the world; and it was the subject of sedulous attention at all the international congresses of which I have spoken. The results have been already satisfactory and full of practical advantage, and they will become still more so when the inquiries which those congresses have organized shall have submitted for comparison the judicial systems of all lands, described by those who are best acquainted with them. In this good work Ireland has done more than her part, under the supervision of Dr. Neilson Hancock; and I owe it to that very eminent statistician to quote from a letter addressed to me by Mr. Hammick, of whom I have spoken already, and whose absence from our Meeting I sincerely lament, the remarkable statement, that "the Irish Judicial Statistics are unequalled in Europe for skilful arrangement and lucid exposition."

The changes in the social state of Ireland and the legislation of latter years have fixed attention on our County Courts, and made some reforms in their procedure and some extension of their jurisdiction very desirable. The Land Act creates new exigencies in connexion with our agricultural and commercial life, and they must be satisfied by a moderate and carefully considered reform of institutions which have worked well and command the confidence of the people. This is one of the most important matters which can receive the attention of the Legislature; and I am glad to say that a beginning of improvement has been made in the last session, by an act which gives the chairman power to adjudicate, in small cases and with certain limits, although *bonâ fide* questions of title may have arisen. The want of this power has often produced a denial of justice to suitors whose poverty has forbidden them to seek it in a superior Court, with the frequent consequences of lawless contentions, violent assaults, and sometimes lamentable homicides. The humble man who is wronged, in fact or fancy, and has found all available legal tribunals closed against him, takes the law into his own hands and becomes his own avenger. I hope this great mischief will now exist no more. But the extension of jurisdiction in title-cases and the further concession of a limited right to deal with transactions of partnership are only, I trust, the heralds of a more comprehensive measure, giving to our local courts, with such modification as may be necessary, the equitable jurisdiction already possessed by the county courts of England.

You will, I am pleased to say, have the opportunity of hearing a paper on Land-Tenure, prepared by Sir George Campbell, the late Lieutenant-Governor of Bengal, who is eminently qualified to speak with authority on that momentous subject, and to whom the people of this country owe serious obligations for the counsel and assistance which his great ability and large experience enabled him to afford during the discussions which preceded the passing of the Irish Land Act. Of that Act, generally, I have no purpose to speak here. It has been in operation for too brief a time, and its provisions have yet been too little interpreted by judicial exposition, to warrant a confident pronounce-

ment on many points connected with it. I believe that it has already been of signal advantage, and will yield far greater benefits hereafter. But I refer to it now only that I may say a word of its purchase clauses, which—and the best mode of giving them vitality and effect—are worthy of the attention of all who care for the prosperity of Ireland. As to those clauses, there was no controversy in Parliament; they passed with universal approval through both the Houses. They recognized, with all the authority involved in so rare a unanimity of acceptance, the value of diffused proprietorship of land amongst our agricultural classes. It is impossible to overestimate their importance to the progress of this country in industry and order. Yet they have a very inadequate operation, and remain almost a dead letter on the Statute Book. I learn, from a report of the Commissioners of Public Works, that, since the passing of the Act, 338 tenant farmers have purchased their holdings, comprising an acreage of 22,116 acres, of which the annual rent amounted to £13,141, at a gross cost of £319,522, including advances from the Commissioners of £192,066. The report informs us, further, that the applications of tenant farmers for loans under the Statute have diminished instead of increasing, and that the purchases of one year have been 206, whilst only 106 were made in that which followed. These facts are disappointing in a high degree; and I call attention to them in this place that, if possible, the causes of the disappointment may be ascertained and done away, and free and fruitful action given to legislative provisions amongst the very best which have ever been vouchsafed to us. Of course I cannot here discuss so large a question; but I may indicate my own opinion that, in order to the effective working of those provisions, it will be necessary to facilitate still further the transfer of land in small proportions, by cheapening conveyances and validating titles at a small expense; and that for this purpose it will be essential to extend the operations of the Record of Title Office beyond the narrow sphere within which Parliamentary opinion confined it when it was originally designed, and to make it effective—as it has never been, though years have elapsed since it was opened—by the application of the principle of compulsion, without the aid of which old habits, ignorant dislike of innovation, and powerful class interests will continue to nullify its influence. The purpose of the Legislature, to secure a complete and permanent register of all dealings with property in the soil, is of high policy and plain necessity, and must not be baulked by the supineness or the obstinacy of individuals whose own best interest will be promoted when they are forced to aid in carrying out that purpose. In addition, it will be necessary to reconsider the fiscal arrangements of the Office as well as of the Landed Estates Court to which it is attached, and to localize their action by the establishment of District Registries of easy access for small transactions and with fees too moderate to bar approach to them. These seem to me the outlines of a reform long desirable, but heretofore difficult from the *vis inertiæ* of some and the active antagonism of others, which should promptly be undertaken by Parliament, and has already in principle received its sanction by its general approval of the Bills introduced by Lord Cairns during the past Session. It is essential to Ireland, if we would have the action of a beneficial law no longer paralyzed, and the passionate eagerness with which the Irish people covet the possession of the soil indulged legitimately and within the limits of the law; so that, instead of finding it often identified with agrarian crime, we shall see it become subordinate and ancillary to the equitable settlement of the country and the lasting contentment of its people, by prompting them to obtain, through honourable industry and manly effort, that position of secure and independent proprietorship, which, according to all our experience of human nature, will lead them to identify their individual interests and objects with their duty to the State, and make them loyal and law-abiding citizens.

There are other topics on which I could willingly address you, but must remember my promise and conclude—only observing that I should more strongly feel the difficulty of adequately discharging the duties of a position which has been held by Lord Derby, Lord Littleton, the late Archbishop Whately, the present Chancellor of the Exchequer, and other very eminent persons, were I not sustained by so many men of high capacity and established reputation, with whose aid I trust that our meetings may be made agreeable, instructive, and of some public utility.

On some Practical Difficulties in Working the Elementary Education Act, 1870. *By* Lydia E. Becker.

The Elementary Education Act of 1870 contains provisions whereby the compulsory attendance at school of children between the ages of five and thirteen may be secured. In consequence of the action of school-boards under these provisions many thousands of children are now attending school who did not attend previously; but the effect of the compulsory action has not been altogether favourable. In Manchester, while the number of scholars in the district has been increased by 13,000, the average attendance at some of the best elementary schools has been lowered as a direct consequence of the compulsory action of the Board. The Manchester Board practically limited the service of notices to cases where the children had made 50 per cent. of attendances. The people rapidly discovered that they were not interfered with if the children had made half the possible attendances; thence arose an impression that half-time satisfied the requirements of the Board and of the Act, and this caused a lowering of the average attendance in the best schools. If a minimum rate is fixed on as a concession to the weakness and needs of the very poor, that becomes practically the maximum for the whole district, and the general rate of attendance is lowered to it.

One of the greatest practical difficulties, especially with regard to girls, is the domestic difficulty. Houses have to be kept in order, babies have to be nursed, fathers' dinners have to be taken, &c. Girls are kept from school to do these things; and when there are no girls, boys are frequently detained for these purposes. It appears open to grave doubt whether it is really necessary, in order to teach a child reading, writing, and arithmetic, to require two school attendances per day. It is suggested that, with properly organized schools, children who attended once a day regularly would be able to pass the Government standards as readily as they do now. There is a large proportion of cases where the earnings of the children stand between the parents and pauperism; and the question suggested is, whether it is most in accordance with sound economic science to require that the children shall be sent to school at the cost of throwing the parents on the parish, or to allow the schooling of the children to be sacrificed to the exigencies of the poverty of the parents.

Reform in the Work of the Medical Profession. By Miss Beedy.

Workmen's Dwellings from a Commercial Standpoint. By W. Botly.

Principles of Penal Legislation. By the Rev. J. T. Burt.

I.

The elementary principles on which penalties ought to be regulated are not generally agreed upon.

Penalties are, at the present time, regulated upon three different principles.

i. The principle of retributive justice. This principle is now generally repudiated in theory; but it is still largely acted upon in the administration of punishment.

ii. The principle of reforming offenders by a course of moral training. This principle is not allowed by practical politicians; but it has influenced modern legislation.

iii. The deterrent principle. This principle accords with the true theory of punishment, subject to limitations.

The deterrent force of penalties is limited—

1. By defective mental capacity in a large portion of the population;
2. By excessive pressure of external circumstances, especially by want.

The attempt to extend the deterrent force of penalties beyond those limits will be, to a great extent, futile; and all useless punishment is both inhuman and impolitic.

The perfection of a penal code will be found in the deterring from crime to the greatest extent practicable with the infliction of the least possible amount of punishment upon those who incur the penalties.

II.

A second principle is required for regulating the *methods* of punishment.

By the fact that crime is committed, the population is divided into two classes. The criminal class is composed of persons in whom the deterrent force of penal laws is overborne, either from defective mental capacity or from an excessive force of positive incentives to crime.

The limitations to the deterrent force of penalties indicate that excessive severity of punishment will not be employed with success in combating those causal influences in these persons.

The dealing with these persons is a distinct problem from the dealing with the population generally.

This secondary object of penal legislation is to be arrived at by adapting the methods of punishment to the causes in which the different forms of crimes originate.

The solution of this problem requires:—

i. An analysis of the causes of crime.

These may be classed as

1. Internal and External.
2. Negative and Positive.
3. Proximate and Remote.

ii. An analysis of the moral and material influences of the available methods of punishment.

The purely penal element of punishment is to be distinguished from its accessories, whether they are inseparable from it or intentional additions to it.

The purely penal element ought to be addressed to the criminal passion. The accessories of the penal element must supply the influences for correcting the internal and for remedying the external causes of crime.

III.

Five kinds of punishment in use enumerated:—1, Capital punishment; 2, corporal punishment; 3, imprisonment, of which penal servitude is one modification; 4, restricted or conditional liberty; 5, fines.

The extent to which these several kinds of punishment were used in the year 1872 was as follows:—1st, thirty persons were sentenced to death, of whom fourteen were executed; 2nd, 837 persons were sentenced to be whipped; 3rd, the commitments to prison were 158,141; 4th, 1514 persons were released under "tickets of leave," and others were sentenced to police supervision without penal servitude, and 18,930 persons were released upon bail under sureties and upon their own recognizances; 5th, the number of fines inflicted was 281,934.

The results obtained from imprisonment considered. The recommitments not a fair test of its effects. The rate of the recommitments is generally misapprehended. The rate, correctly calculated, shows that of all persons committed to prison once 75 or 76 per cent. do not return. After repeated commitment the rate increases rapidly.

The imposing of restrictions or conditions upon liberty is a method of treatment which is now enforced every year upon about 2000 of the worst class of offenders, and upon 18,000 or 19,000 persons accused of the lighter forms of crime. It is proposed to extend this method of treatment to some of the 100,000 persons who come between these extremes of criminality.

The Increase of Drunkenness among the Working Classes and the Causes of it. By the Rev. W. Caine, *M.A.*

A scientific writer in one of our periodicals, after describing the effect of the electric telegraph in promoting civilization in our own country and over all the

earth, makes a saddening remark:—"But civilization," he says, "has two aspects, and, side by side with the development of a wonderful scientific invention, we must place the fact that in 1872 the quantity of spirits consumed in the United Kingdom was 26,872,183 gallons, being 2,708,539 gallons more than in 1871." So said this writer in 'Chambers's Journal,' in March 1873. Now we have the shame of confessing that, during the year 1873, there has been a very large increase in the consumption of intoxicating drinks in the United Kingdom. We used last year—

Home spirits	28,908,501	gallons.
Foreign spirits	10,223,706	"
Wine	18,027,104	"
	57,159,311	"

In addition to this we used 1,076,844,942 gallons of beer, and about 18,500,000 gallons of British wines, cider, &c. When we consider the enormous quantity of intoxicating drink which has been consumed, we need not wonder at the increase of crime, especially in our manufacturing districts, where wages have been so high and trade so prosperous.

The statistics of the county gaol, Manchester, in which the author was chaplain during the years 1868 and 1869, are truly startling. This prison receives all the criminals in the hundred of Salford, except those from the city of Manchester, for whose accommodation a special gaol is provided.

For the year ending September 29, 1869, the committals for drunkenness to the county gaol were 2003, viz. 1324 males and 679 females.

For the year ending September 29, 1870, there were 2322—males 1518 and females 804.

1871	....	2332—males	1603,	females	729
1872	....	2784	"	1900,	"	884
1873	....	3208	"	2095,	"	1113

We learn from these figures that in four years the committals for drunkenness have increased 60 per cent.

In Manchester, during the twelve months ending the 31st of March last, 9150 persons were apprehended by the police and brought before the justices for being drunk and drunk and disorderly in the streets. Large as this number is, it is less by 903 than the number arrested in 1872. The diminution in 1873 was doubtless owing to the operation of the Licensing Act and the earlier closing of drink-houses, as comparatively few were arrested during the night, and there was a decrease of 467 in the number arrested on Sundays. But it appears from the monthly reports of the chief constable that the number arrested for drunkenness is now again increasing.

But the committals for drunkenness to our prisons do not show the full extent of the evils which follow in the train of drunkenness. Very many of those committed to gaol are drunkards, though convicted of other offences of which they would never have been guilty if it were not for their drunkenness. The committals to the county gaol, Manchester, for all offences were, in 1869, 6532—males 4900, females 1632. In 1873 the total committals for all offences were 7210—males 5051, females 2159. Here is a lamentable state of things! The committals of females have increased in four years from 1632 to 2159. Female drunkenness is increasing to a frightful extent (60 per cent. in four years), and their drinking leads to the commission of other crimes. We are told by Plutarch, in his comparison of the lives of Numa and Lycurgus, that in the early ages of Rome women were strictly prohibited from tasting intoxicating wine; and other ancient writers tell us that they were punished with death for their crime, just as if they had committed adultery, "because the drinking of intoxicating liquor was regarded as the beginning of adultery." When will English legislators be as wise as Romulus and Numa so far as to prevent females from using these poisonous drinks? A drunken woman was a very rare sight in ancient Rome, but in one prison in England the author saw in two years about 3000 drunken women. He knows no greater reproach to Christianity than this most horrible fact.

In the Liverpool Borough Gaol during the year ending September 30, 1873, the committals were 12,420; of these, 5747 were males and (dreadful to contemplate) 6673 were females. Of these 12,420 committals, 8322 were under the care of the Roman Catholic chaplain, the Rev. Father Nugent; and it is sad to think there were 4742 women under his care—in fact more females than males, as the males were only 3580. Under the Protestant chaplain there were 1931 females and 2067 males. The author distinguished the sexes in this manner in order again to draw attention to the absolute necessity there is of imposing some check on the drinking of alcoholic liquors by females, if the comfort and happiness of the homes of our people ought to be maintained. Napoleon the First said the great want of France was "good mothers." If female drunkenness continues to increase as it does now, the great want of our nation also will be "good mothers." Of these committals, nine out of ten have been caused by indulgence in drink.

The author spoke of the drunkenness in the county of Lancaster. From the Judicial Statistics he finds there has been a corresponding increase of drunkenness throughout the whole of England. The apprehensions for drunkenness in England and Wales, during the last eleven years, has been as follows:—

1863	94,745	1868	111,465
1864	100,067	1869	122,310
1865	105,310	1870	131,870
1866	104,368	1871	142,243
1867	100,357	1872	151,084

As to the apprehensions for drunkenness in 1873, Mr. Cross, the Home Secretary, in his speech in the House of Commons on April 27, when moving for leave to bring in his Licensing Amendment Bill, said, "When we look at the facts which I am about to place before the Committee, we must acknowledge that in their broad outline they certainly do present a formidable state of things. I find that in 1873, in England alone, no less than 182,000 persons were proceeded against for drunkenness." From this statement it appears that in 1873 there was an increase in the apprehensions for drunkenness of not less than 30,000.

To what are we to attribute this increase of drunkenness?

1st, the author thinks, to the higher wages received by the working people;

2nd, to the shorter hours of labour; and

3rd, to the increase of facilities for the procuring of the drink. The sale of drink in grocers' shops is, the author believes, the chief cause of the intemperance amongst women; and an earnest effort ought to be made to remove this source of temptation out of their way.

On the Privileges over Land, wrongly called Property.
By Sir George Campbell, *D.C.L., K.C.S.I.*

The author said he had adopted this title for his paper in order to distinguish between absolute property and those privileges which he would rather call limited property. What he meant to express was, that land was not an absolute property, but a limited property, a privilege conferred by the community for the benefit of the community, and subject, to a certain extent, to the convenience of the community. For instance, he might do what he pleased with his handkerchief, and the law recognized his absolute property in it. But, as regarded land, his contention was that there was no absolute property of that kind; that the land, made not by man but by God, was rather the property of the nation, and that certain limited privileges were conceded to individuals for the benefit of the nation, and must be held subject to the will and convenience of the nation.

It had been said that the man who first enclosed the common land was a robber; but he did not think that view was justified, for it was necessary that the land should be in some degree enclosed in the first instance to protect it against the beasts of the forest. He might quote experience of his own among aboriginal races to show that this early property was in fact not continuous, and not injurious to a community, for such land was never held in permanency; but as soon as the

primeval fertility of the land was exhausted, the people moved to another portion and repeated the process there.

The land which was originally held by tribes became subject to periodical redistribution; but as its cultivation became more settled, and improvement more common, the practice of redistribution gradually fell into desuetude, and the shareholders retained their shares. That process the author had seen step by step going on. Not only were the grazing lands and also wood, water, and other things held in common, but the inchoate individual rights were in very many cases subject to the rights and convenience of the community in general. A holder could not alienate his individual holding to a stranger, arable lands were unenclosed, and there was a universal right of way so long as the growing crops were not unfairly damaged; also there was a right of common pasture when the crops were off the ground. It was, indeed, one of the most painful features of our modern civilization that the land was so far enclosed that the people who did not own it were almost altogether confined to the highways.

The village community was the earliest tenure in Europe and Asia in which a right in land could be traced. Sir Henry Mayne had well shown that traces of that kind of tenure exist in our own and in neighbouring countries. There were large traces in England and Scotland; and Sir Henry Mayne had found one place in Scotland in which the ancient tenure still existed in full perfection, where the "infield" was permanently divided among the different members of the community, the "outfield" divided temporarily according to the circumstances and necessities of the season, and grazing land quite undivided. In Ireland the tribal rights, which undoubtedly had existed, were only superseded by conquest. In the Highlands of Scotland, where the people and their institutions were cognate with those of Ireland, the same rights prevailed, which were abolished partly by conquest after the rebellion, partly by the lawyers, who applied the principles of feudal tenure to the estates of the Highland chiefs; and thus, while the chiefs were constituted feudal holders, their co-proprietors, the clansmen, were dispossessed and in a certain degree expatriated. Under the feudal system the rights of the Celtic people were in theory wholly ignored, and the villagers were treated as serfs bound to the soil. He thought it very clear that the system under which the serfs became adscripti glebæ was adopted to prevent moving from one part of the country to another, which might have given certain rights to the subject people. There were two rights which mitigated despotism over a subject people: first, the right of rebellion; and secondly, the right of running away. That of rebellion was very important. He need not say more of that at present. The right of running away was not sufficiently understood. He had seen a great deal of benefit obtained from that right. When a man was much oppressed it was a very great right that he should be enabled to run away, to desert his master, and enlist himself under the banner of a new one. In days of anarchy, when lords were ready to turn their hands against each other, it was necessary to establish a kind of trades' union to prevent that emigration. One way of doing that was by passing a law to prevent serfs from running away. But even the binding of the serfs to the soil gave them certain rights in connexion with the soil, so that what was injurious in one way was beneficial in another. The other day, in Russia, on the occasion of the emancipation of the serfs, the view put forward by the latter was—"True, we are yours; but the land is ours." Philologers believe that some of the modern languages are not corruptions of the ancient ones, but revivals of popular languages of ancient days. So also with regard to the inferior rights to land, the author was inclined to believe that the lower classes of tenure which cropped up in altered forms under the feudal system were not merely what the lawyers held them to be, the produce of indulgence and prescription, but a revival, in another form, of the old right of the subject people, long suppressed, but never wholly extinguished. Such he believed to be the English copyhold tenure. In Ireland the ancient rights of the people had been recently recognized in the Land Act. The numerous commons in England were, no doubt, very substantial remains of the old rights of the communal holding. The right of primogeniture he believed to have arisen simply because the title to land was not an absolute right. It was evident that some one person must be responsible for the duties of an office, which duties could not be divided amongst the

members of a family. Hence it was that, when the holding was of the nature of an office, the succession went to the eldest male. We should be very careful how we do away with office-tenure by abolishing the right of primogeniture. He much suspected that such a change would be more in the interests of plutocracy than of the people. He doubted whether it would bring us one step nearer to a wider distribution of the land among the people, properly so called. It would free the landlords from the burthens of special taxation, which were the legitimate successors of the service burthens of former days. In India the establishment of an ordinary law of property applied to land had produced most ruinous effects. Lord Cornwallis sought to create an Indian aristocracy by turning the land-revenue collectors into landholders. But the law of primogeniture not being carried out, the result was that in Bengal there was scarcely an estate that was not held by a great many holders under every variety of tenure, and the duties of the landlords were thrown back again on the Government. After an experience of seventy or eighty years, that was a difficulty which they had now begun most thoroughly to realize in India, and it had been especially realized in connexion with the recent famine. When they tried there to insist on the landholders doing their duty to the people and their tenants, the particular responsible landlord could not be got hold of, so vast was the variety of rights and interests, inferior and superior, on the estate. The Government had therefore been obliged to step in, and do the duty which it was originally supposed the landlord would do. If the division of property among all the children were made compulsory in England, he doubted whether the effect would be, on the whole, good. If by such means the land came to be divided generally among the people at large, he would be in favour of it; but he suspected that the more such land was brought into the market the more it would go to plutocrats, and as little as ever to the people. Moreover, people holding a divided estate, treating their portions as absolute property, would be far less liberal landlords than a single owner, would be less restrained by social bonds, and would be more likely to seek to make the most of their property. Under such a system, for instance, tenant-right in Ulster and other parts of Ireland would never have assumed the shape it has, and it would not have been possible or, at all events, so easy to establish it by statute as it has been now established. It would also be injurious in inducing younger sons to remain at home with less property than their fathers, as Frenchmen and others did. In Scotland especially it would be a great misfortune if younger sons had not gone out into the world to carve fortunes for themselves. There is still a great deal of the aristocratic spirit in this country. As soon as a man becomes rich he seeks to rise into the aristocratic class. We have a great respect for lords, ladies, and swells. So long as this lasted he doubted whether we ought to throw away those duties to the public which the moral persuasion of public opinion imposes on the holders of great estates under the law of primogeniture. A great landlord, subject to the compulsion of public opinion, was likely to do more, for instance, in the erection of workmen's dwellings, than a man who buys property as a speculation; and he believed, as long as we treat those great landholders as office-holders, we may, by moral compulsion, force them to do their duty to the public, which they would not do if they were allowed to muddle away their estates. At the same time he thought a divorce of the people from all rights in the land would be the greatest of all evils, and would lead to revolution. He thought that, rather than look to any petty measures to promote the subdivision of estates, we should rather look to the growth of tenant-right as a legitimate mode of giving a large proportion of the people a real interest in the land; and by tenant-right he meant such a privilege as would give the tenant some value in his holding, and some feeling that he might improve without fear of being unfairly turned out or risk the loss of his property. With reference to the Irish Land Act, men in high position in Ireland agree that it has immensely raised the position of the Irish tenant; and, on the other hand, complaints were not heard of ruinous confiscation on the part of the landholders. He believed there was no doubt that property in Ireland had actually risen in value since the introduction of that Act; and that was a true test that the landlords had not been injured. They had heard that the Land Act had, in the main, been successful, and only wanted improvement in its working details. If honestly made the best of, and improved in a true spirit of sound legislation, he

had no doubt of its ultimate success. In England and Scotland the question stood on a different footing; but it was becoming more and more evident that the farmers would insist on obtaining more security for their interests than at present existed.

On the Teaching of Hygiene in Government Schools.
By RICHARD CATON, *M.D.*

Notwithstanding the effects of sanitary legislation, the death-rate among the poorer classes in large towns, in the manufacturing districts especially, continues to be very great. The duration of life among this class averages from twenty to twenty-five years in many of the larger centres. As town population is rapidly increasing, and that of the country districts diminishing or remaining at a stand-still, the injurious influence of town residence on the health and vigour of the people is likely to become a very serious question, and calls for great earnestness in sanitary reform.

Hitherto sanitary legislation has been solely directed to the amendment of the outward circumstances in which the people are placed—such, for example, as the avoidance of overcrowding, the improved construction of dwellings, the establishment of good systems of drainage and water-supply.

While such reforms as these are of the highest importance, there is yet another direction which efforts at the improvement of the health of the people might take, viz. that of reforming their habits of life. The absolute ignorance of the laws of life and health which prevails among our lower-class town population is disastrous in the extreme. Were all external sanitary conditions made as favourable as towns permit of, the mistaken habits of life of the people would of themselves cause a high mortality.

The object of this paper is to suggest that the required knowledge might be diffused among the people through the agency of our National Schools. A brief, simple catechism, explaining the rules of health, and pointing out how greatly the comfort and length of life depends upon their observance, could be readily taught to the elder scholars. Such points as the following, dealing with the affairs of their every-day life, would, I think, be readily understood:—The importance of fresh air and free ventilation in houses; the dangers of sleeping in close crowded bedrooms; the danger of breathing sewage-gases; the value of sunlight, of exercise, of the free use of pure water; the main rules of diet, such as a statement of the kinds of nutritive foods necessary for health, and the forms in which they can best be obtained; the proper dieting and management of children; the disastrous effects of intemperance; simple rules as to clothing; the dangers of unhealthy occupations, the modes of escaping their injurious effects; the requirements to be kept in view in selecting a healthy dwelling-house, &c. It is true that our system of education is yet crude and undeveloped, but every year will increase its efficiency, and render such teaching as this less difficult. If the object of education be to prepare for life, I cannot conceive any thing more essentially a part of it than this: to know how to live must surely be as important as how to read, write, and count; from the want of such knowledge thousands of the people die needlessly every year. Such teaching as the above would be a means of helping them intelligently to improve their own condition, and, along with other sanitary measures, it might reasonably be expected to lessen the excessive mortality at present existing among the lower classes.

On the Compilation of Statistics, illustrated by the Irish Census Returns.
By GEORGE ROBERTS CROWE, *Belfast.*

The author suggested a system of compilation by which census returns, or any other statistics which it would be necessary to produce from a large mass of data periodically, could be prepared within one half the time and at one half the cost at present expended, and show the results in a more exact, varied, and utilitarian light, without causing any disturbance of existing formulæ or precluding comparison

with previous returns, for which purpose he invented an instrument designed to make four marks or cuts, viz. a straight line, a curve, a right angle, a point; and with incisions or cuts made by it he proposes to have the data registered. These cuts can be made to show thirteen aspects of a leading question; and in illustration of his method he suggested their applicability for recording the "religions" of the people in connexion with *their ages and occupations*, thus—

A Protestant Episcopalian might be shown by what he called the	Cut perpendicular.
A Roman Catholic	„ right incline.
A Presbyterian	„ left incline.
A Methodist	„ horizontal.
An Independent	„ right curve.
A Unitarian	„ left curve.
A Baptist	„ upper curve.
A Friend	„ lower curve.

The part of the instrument describing a right angle to be used in a similar way for other denominations, those forms of faith of which there are but few to be specially noted in the margin. Therefore, by making the incision indicating the religion, three conditions of a person would be registered instead of two, as at present, thereby saving one third of the time and giving the additional information in a new and interesting connexion; for the age would be shown with the form of faith the person professed as well as with the occupation in which he was employed. If the improvement were to extend no further, *the tabulating forms at present in use would answer for this purpose.* But he proposes to include by the same operation the educational and matrimonial conditions of the people; for which purpose he would have the tabulating sheets divided into groups of prismatic colours (civic and rural sheets to be prepared differently), each group to be applicable for one occupation, and each colour to have a special significancy (for those occupations for which an elementary education is the first essential only two colours would be required), thus—

A red colour could show that the person cut in there-through was	Married, and could "read and write."
Orange	Married, could "read."
Yellow	Married, "illiterate."
Green	Unmarried, "read and write."
Blue	Unmarried, "read."
Purple	Unmarried, "illiterate."

If only three colours were used, they might indicate *either* the educational or matrimonial state, viz.:—

Read and write	or	Married	by	Red.
Read		Unmarried		Orange.
Illiterate		Widowed		Yellow.

But if the first plan were approved there should be no difficulty in carrying it out. As the six subjects (N.B. all of great statistical affinity) appear on one line on the census-paper, with the assistance of these statistical mnemonics he thinks they could be easily retained in memory for a couple of seconds till fixed in their chamber on the sheet by the incision; however, he suggested that at this important work a superior class of clerks should be employed (some of the "supernumeraries" of Government offices might be drafted for this special duty), the subsequent work of totting and extracting to be performed by less experienced persons, thus inverting the order that at present obtains. To obviate any difficulty that might arise in the subsequent analysis from the concrete or synthetic nature of this method, and at the same time to economize time and extend the efficiency of the compilation, he proposes that the record should be made on six (or more) sheets simultaneously by placing one over the other, and having the incision made through them, thereby opening up a field for a valuable division of labour; for the forms could be divided,

after the enumeration had been completed, among six clerks, each clerk to get on simple duty to attend to in connexion with his sheet. For instance, one clerk migh condense in the place for totals, whether vertical or transverse, all the informatio respecting education, another that relating to matrimony, a third to religion, and s forth; or one could count up all the "perpendicular cuts" in each column, whicl would give the numbers of each age, of each trade, who were "Protestant Episco palians;" while the transverse totals of the same cuts would give the numbers o *all ages* of that religion and occupation, the coloured chambers in which thos totals *should* appear affording an analysis of their connubial and educational conditions, showing how each was repressed or encouraged by the other. The nex clerk would in like manner work on the "right incline cuts," which would giv the same particulars regarding "Roman Catholics," and so on for "Presbyterians," "Methodists," &c. In connexion with the tabulation of these conditions of th people, viz. the "occupation," "age and sex," "religion," "education," and "matrimonial state," he suggested that the "house census" might be shown to the left o the form; the colours and cuts to show the "classes of houses," "numbers of families," &c., from which would be seen how those conditions affect the domestic comfort means of living, and position in society of our people. The author thinks that all th data provided by the census-paper, "Form A" (excepting that relating to disease anc death), might be tabulated by two manipulations; the second tabulation to show th "birthplaces" of the people, the "relation" of the members of each household t the head of it, the state of education of the "married," unmarried," and "widowed," the "ages and sex;" the ages to be shown by the *cuts* in school periods of "unde seven years," "twelve years," and upward—which plan, he thinks, would be mos suggestive, all showing, from an ethnological point of view, how the idiosyncracie of race affect us and tend to make our populations more or less homogeneous; however, the skilled statistician might group those conditions in a more useful manner A great deal of the work could be done by "task" by people at their own homes Even the blind might do it; for the cuts would appear on the obverse of each sheet slightly in relief, and the acute sense of touch which they possess would enable them to distinguish the symbols. However he would not recommend th experiment; he mentioned the matter parenthetically to show how the syster might be made available for the instruction of that afflicted class. For the compilation of "Vital Statistics," the writer considered the method would be peculiarl valuable, seeing that our occupations and social conditions have such an effect upo our health and longevity. The circumstances calculated to repress or occasio certain forms of disease could be made to converge into the column in which th disease would be specified; and the exceptional data required for some classes, suc as the "blind," "deaf and dumb," "insane," "idiotic," "decrepit," &c., could be a it were eliminated into the chamber under the head of any of these afflictions and as our diseased, though so many, are yet comparatively few to the genera population, the work would be peculiarly facile regarding them. Criminals an paupers are at present reported on in the status of disease; the causes and temptations that led to their degraded state could be ascertained with greater nicety and measures founded thereon calculated to drive vice and misery from society The author submitted that by this system the chief difficulty that statistica scientists have to contend with could be removed; for as at present, owing t the great labour and delay in compilation, he is obliged to contract his desire within the limits of what he considers practicable of attainment, that more subtl and refined analysis of conditions necessary to show statistical truth in all it bearings is too often not made, on account of which erroneous conclusions regarding some cases or localities are arrived at; but as by this method any *twelve* subsidiary conditions relating to any *one* leading subject can be registered by tw simple operations in a most intimate and truthful connexion, the field of inquir can be enlarged, while at the same time the work would be diminished, therefo many things that at present appear anomalous or strange, and which are now onl accounted for by surmise, could be placed in a true statistical position. Also ne features of much interest would be necessarily shown; for instance, in the Iris census returns, the occupations of the married and unmarried are not given (ho requisite in preparing factory bills!); but this method would show them in connexio

with the age, sex, religion, and education, all in a concrete manner or in their several relations. He also submitted that by it records could be kept at each dispensary district of the diseases of the locality *pari passu* with their occurrence, showing how they were "begun, continued, and ended;" one of the incised copies to be forwarded periodically to a central office to be tabulated for the advancement of medical science and the consequent sanitary benefit of the community. Doctors could, on a properly arranged table, register the leading particulars of each day's work in a few minutes.

In conclusion, he attributed the delays that occur in the publication of census and other standard statistics to the apathy of the public regarding statistical science; for if it were more generally appreciated, the laws of demand and supply would soon provide a remedy. By a proper arrangement of the statistics of his business, both as regards "plant," "materials," and "money," the merchant or manufacturer could learn when, where, and *how* to repress expenditure and develop income, and from an intelligent examination of our national statistics see new fields for the investment of capital. Narrow and sectarian views too often restrict the utility of a census, as is the case in that of Great Britain, which affords no information respecting the religion or education of the people, which was so much wanted in connexion with recent legislation. If statistics were better understood, we would very soon have a department at Whitehall where all our national facts would be registered with mathematical precision and published with the regularity of a gazette, so that merchants, manufacturers, and philanthropists, as well as statesmen, could obtain standard information on all subjects of importance. It could supply at a day's notice the Parliamentary returns so frequently called for by the advocates of new measures and now provided with such delay and expense, and, what would be perhaps of greater importance, it could afford correlative information to the opponents of them fully and promptly.

The Economic Law of Strikes. *By* W. H. Dodd, *A.M., Barrister at Law.*

At the outset it is necessary to inquire if there be a "law." Economic science has been put on its defence recently by writers both in America and England. The "law" of abstract political economy on the subject is modified in actual fact in two ways. It is modified by the nature of profits themselves. The first element in profits is remuneration for saving, or interest; the second is remuneration for risk, or assurance; the third is the wages of superintendence, including all elements not included under the first two. The first two elements are equal or nearly equal over all trades and manufactures in the same country at any given time; the third varies from trade to trade, and from individual to individual. It is this third element that a combination of labour attacks; and on this very account a strike is more difficult of settlement, since the amount of the profits is unknown to those attacking them. But the economic law is also modified by historical or local circumstances; and here it may be well to inquire what *is* the law. The rate of wages depends on the amount of the wage-fund divided by the number of labourers. The first element in this (wage-fund) is made up of all capital other than fixed capital, and all wealth not capital devoted to the employment of labour. Again, profits depend solely on the cost of labour. If we assume A to be the finished commodity, $W+P=A$, and therefore $A-W=P$. Lastly, as regards exchange. Articles will exchange in accordance with the wages and profits expended on them, or $W+P=\overline{W'+P'+}$. This is briefly the law of political economy; but it is modified locally and historically by a variety of considerations. In a place, for example, where there is only one manufactory, such as Bessbrook, the relations between employer and employed are open to modification from the sagacity and wisdom of the employer in making more profits than usual in the manufacture, from his being content with less, or from his deliberately sharing his profits with his workmen. On the other hand, they may be modified by the ignorance or selfishness of the employed, or by factious and evil-minded agitators. Again, a particular manufacture may have exceptional advantages in locality, and may for a series of years obtain a kind of monopoly. Capitalists in

such a place get an advantage in the nature of rent. Now, whether they can maintain the monopoly depends on whether the natural advantages are being well managed, whether they are not overborne by corresponding disadvantages. Whether the capitalists can grasp all those benefits or be compelled to share them with the labourers depends on the degree of skill required for the work, and the length of time required for the obtaining such skill. Whether, again, the monopoly be permanent or temporary must be considered. If it be temporary, and fresh hands not immediately obtainable, the owners must share their profits with the workers. If the manufacture be overcrowded, the remedy is not to lower wages, but for the weakest or least competent employers to discontinue production.

Manchester has advantages for cotton manufacture in its coal and iron and knowledge of machinery. When these are overtaken (if they be overtaken by America) we will not perhaps see the anomaly of the raw material being brought thousands of miles to be manufactured, and sent back thousands of miles to be sold. Belfast has advantages in the flax-fields of Ulster and in the knowledge and skill of its manufacturers, slowly acquired and carefully treasured, in banking accommodation, facilities for locomotion, and otherwise. Whether the advantages are abused or not, whether the manufacture has not been pressed to a point beyond what the natural advantages would warrant, whether the employers can keep all the extra gains arising from such advantages or must share them with the workers, depends on the wisdom and sagacity of the manufacturers, on the confidence placed in them by the workmen, on the general state of trade, and other considerations which abstract political economy rejects. But though feudalism has ceased to be sole arbiter in land-tenure, and though the relations between capital and labour are supposed to be founded solely on contract, political economy cannot disguise, and does not seek to disguise, the fact that friendliness and sympathy and cooperation between employer and employed, as between landlord and tenant, are not only the best security for social content, but are also the way to utilize to the utmost the productive forces of nature.

On the Ulster Tenant-Right. *By* Professor DONNELL, *M.A.*

The Ulster Tenant-Right, up to the introduction of the Irish Land Act, was almost unknown in England, and but imperfectly understood outside the limits of Ulster. Mr. Gladstone's speech on introducing the Bill brought it under the notice of the empire. This speech contains an admirable exposition of the Ulster Tenant-Right. The Ulster Tenant-Right is the tenant's right of continuous occupancy of his lands, subject to a fair rent, which may be periodically revised, and the right of selling this occupancy right at the best price to a solvent and unobjectionable tenant. This right embraces a property valued by Dr. Hancock twenty years ago at £20,000,000, but recent investigations in the Land Courts show that it would not be overestimated at £35,000,000. This right was universally respected by the large landowners in Ulster up to 1838, when the Irish Poor-law was introduced and an impetus given to farm consolidation. Restrictions on the price of the Tenant-Right have in some cases been since introduced; and in other cases the right has been altogether abolished. This arose from the fact that the custom, though as old as the Ulster Plantation and generally observed, had no legal protection. The first section of the Irish Land Act first legalized it. The custom is economically beneficial; it gives security for improvements, and it is the cause of a great saving in poor-rates and police charges. The legalization of the Ulster custom has not diminished the value of the landlord's estate; on the contrary, the sales in the Landed Estates Court show, since 1870, an increase of two to three years' purchase in the value of estates.

The Act has not, as was intended, fully legalized the custom. The leaseholders' tenant-right has not been sufficiently protected. The tenant-right in town-parks and pasture-farms is still without legal protection. The restrictions on the prices of the tenant-right have not been entirely removed. Disputes about the adjustment of rent are not directly investigated. The Courts have been declared incapable of making decrees of declaration of right and of specific performance. These are

blots on the Act, but appear not to have been contemplated by it. Their removal by a declaratory Act would do much to complete the great and beneficent measure of justice to the Irish tenants—the Irish Land Act.

On a New Method for promoting the Sanification of our Cities. *By* CHARLES ELCOCK.

On Political Economy and the Laws affecting the Prices of Commodities and Labour, and on Strikes and Lock-outs. *By* FRANK P. FELLOWS, *F.S.S.*

A better knowledge of the principles of political economy which regulate the prices of commodities and labour, which cause trade to be good or bad, by both employers and employed, would do much to prevent the unfortunate lock-outs and strikes that waste so much of our national resources. In this paper the author endeavoured to show clearly what are the causes which make wages rise and fall, and which cause trade to increase and decrease.

It unfortunately happens that political economy is too often spoken of as a hard, harsh, unfeeling science, and that it is considered to be inimical to the best interests of the wage-receiving classes; whereas, properly understood, it is a light and a beacon to guide these and all other classes; by which individuals, communities, and nations may discover that by which they may earn the most, and which will be best for themselves and the world at large.

The author asked first, What is it that makes trade good or bad? and this was answered by an illustrative argument.

"I will suppose first that by the fiat of my will I could at once double the number of people living on this earth, doubling the houses, mills, &c., at the same time keeping the proportional numbers occupied in each class of trade, agriculture (the increased agriculturists cultivating new land), &c., the same. What would be the result to the various trades and occupations of men, and to the amount of wages earned by workmen, and to the profits of the employers? It will be at once seen from my question that if I double the number of each class of iron-workers, weavers, carpenters, food-producers, and of every other class of occupation, I double the number of each article made, of each sort of food produced, and that I double at the same time the number of consumers for the said articles or food, the wages of each class would remain unaltered; for if double the quantity of shoes are made, double the quantity are wanted; if double the quantity of food is produced, double the quantity is wanted, &c. But suppose (instead of the above case) that I were to double the goods'-producers and goods produced, but that at the same time the food-producers and the food produced remained stationary—What then would be the result?

"Simply this, that there would be a glut of goods'-producers and of goods produced, and a great scarcity of food-producers and of food produced. Consequently the merchants and manufacturers would find great difficulty in selling their goods, and the prices thereof would fall; the wages of the goods'-producers would fall also. At the same time the price of food would rise, there being a scarcity of it in proportion to the demand for it, and the wages of the food-producers would rise also. Of course this is on the assumption that there is no transfer of labour from the goods'-producing class to the food-producing class."

This latter process has in times past been going on with us; for the United Kingdom, the author continued, is the workshop of the world, *i.e.* the goods'-producing country and people. We have increased in times past our population and goods produced faster than the food-producing countries. This has induced the emigration to America, Canada, and Australia to keep up the equilibrium. Individual trades, he said, are affected in like manner. Limitation of production is, he continued, an evil, and the wages of men must be considered with reference to what those wages will purchase. He next referred to the boon of machinery, of cheap production, *i.e.* of abundant production, *i.e.* of not limiting production in order to raise prices. It does not necessarily follow that this means the lowering of the money amount of wages; indeed facts show the reverse to be

the case; but it does mean increasing the amount of things those wages will purchase, or, in other words, of raising those wages. Working men, so called, are termed the bone, muscle, and sinew of the nation; but what would this bone, muscle, and sinew be without the brain and the directing power? The bone and muscle and sinew of one man will do the manual work of one man; the brain and directing power of one man may devise means by which one man may do the work of a thousand. Skilled artisans have high wages because of brain-directing power, machinery, and capital. It is the brain and directing power and the economizing spirit that has created capital and increased wages, and not combinations or strikes; nor can lock-outs permanently lower wages.

The economizing spirit creating wealth and increasing wages was spoken of and illustrated thus:—"Two persons, each having £1000, expend the amount as follows:—The first spends his £1000 entirely upon himself or family, in rent, food, clothes, &c., for his or his family's use. He has thus certainly distributed the £1000 amongst the community—the bakers, grocers, &c.; but at the end of the year, although he has thus spread it abroad, he himself has none of the £1000 left. The second expends his £1000, say, in building houses or in making goods. The £1000 is distributed first amongst brickmakers, masons, carpenters, labourers, &c. in wages for building, and in so far it tends to increase wages by creating more employment; secondly, the £1000 is also distributed amongst the bakers, grocers, &c. as in the first illustration, but by the masons, labourers, &c. instead of by the individual himself, with this result—that the second has expended his £1000, and yet he has houses of the value of £1000 left. Thus he increases the goods or houses produced, and in so far tends to lower their prices or rents, and increases the demand for useful and profitable labour, and in so far tends to raise the rate of wages."

The author, quoting "Man doth not live by bread alone," showed the necessity (apart from mere pecuniary considerations, but still from a politico-economic point of view) of our being civilized and refined, of having clean and healthy houses, of having recreation and leisure, and even some of the refinements and luxuries of civilized life, as tending to increase and strengthen our mental, moral, and physical efficacy, and therefore our creative originating power and our power of work, especially the higher kind of work. He went on, in conclusion, to show the evil effects of strikes, and the tendency they have to drive away trade from particular districts.

On Governmental Accounts, with further suggestions for establishing a Doomsday Book, giving the Value of Governmental Property. By Frank P. Fellows.

On the Study of Education as a Science. By Mrs. W. Grey*.

The first question to be met is that which will be raised by the title of this paper, "Is there or can there be a science of Education?" If the general or even the educational public were polled upon it, the answer would almost certainly be in the negative. The College of Preceptors alone among our scholastic corporations has acknowledged the fact by appointing a Professor of the Science and Art of Education, Mr. Joseph Payne, than whom no one was better qualified for the post; yet the appointment excited some derision among even zealous advocates of national education. It is, however, beginning to be admitted in theory that there is an art of education, and that teachers ought to be taught to teach, although it is not recognized in practice beyond the sphere of elementary school teachers. In every German and Swiss University there is a Professor of Pedagogy, or the art and method of teaching; but here all the secondary education of both sexes is in the hands of those who have never even been taught that there is such an art. Whence this disbelief and distrust in scientific principles and methods in education, while their superiority is admitted by every educated person in all other departments of human activity? The answer probably lies in this, that there is no adequate or general conception of what education is, and therefore of the magnitude and

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complexity of the facts on which a science of education, which can never be an exact, but only a mixed and applied science, must be based. If we had such a conception, giving us a standard by which to measure success or failure, we should at once feel the necessity of scientific methods to realize it. Instead of it we start with a confusion of terms, using education as synonymous with instruction; and the confusion of thought indicated by this misnomer runs through our whole treatment of the subject, theoretical and practical, as is shown in every parliamentary debate and in every discussion of the subject, public or private, especially where the education of the working classes and of women is concerned. It is surely time that this confusion should be replaced by a scientific conception of the process which should result in the most valuable of all products—human beings developed to the full extent of their natural capacity, trained to understand their work in this world and to do it. The conditions of the problem are these:—We have to consider the threefold nature of the human being to be dealt with, physical, intellectual, and moral, together with his power of volition, which makes him a responsible agent, and to distinguish what elements of his constitution are common to him and his species, race, or family, and those peculiar to himself which constitute his individuality. Next come the external conditions under which he lives, physical, mental, and social (which also may be classed as those common to all human beings), those common to all of his time, country, and social position, and those peculiar to himself and forming his individual lot. Throwing out that which is purely individual, and does not therefore admit of generalization, though forming a most important branch of study for the practical educator, there remains the wide field of general facts and forces; and *the study of the combination of these forces, and their resultant influence on the formation of character, is the study of education as a science.* It is at once apparent how vast a field of knowledge is thus covered. We must learn from physiology how to train the body not only to health and strength, but to grace and beauty; from psychology, how to train the intellect and moral nature, how to form habits, which is the master power of education; from observation of human life in the world around us, and from the records of the history of human societies, of religion, art, literature, and science, how to reach the springs of human action, and especially the idealistic or spiritual element, which is the most powerful of all, and from these deduce the right order of education, the right methods of teaching, and the right subjects to be taught, relatively to the age and mental development of the pupil.

The study of education as a science includes the education of nations as well as individuals. Nations have characters as well as individuals, on which their well or ill being depends; and no questions are more worthy of scientific study than how those characters are formed. The statesman is the most powerful of educators, for he helps to form the social atmosphere, which is the most active force in the education of every individual. The educational influence of the poor-law, which was the real Elementary Education Act of England, may be cited as an instance. Of the practical questions requiring solution by a scientific standard, only a few of the most pressing importance can be mentioned. The first is class in education. The impartial comparison of our own system, which preserves social distinctions in education, with that of Scotland, Germany, Switzerland, and the United States, which disregards them, and makes the primary and secondary school and the University parts of one whole, adapted to different ages and degrees of mental development, not different classes of society—such a comparison, including social as well as educational results, would greatly assist us in the gradual remodelling of our scholastic institutions, now going on under the influence of the vast movement of transition which characterizes our epoch. The second problem is that of sex in education; and as there is none that touches such burning questions, so there is none that more urgently requires to be considered in the scientific spirit which seeks the truth only. Whether the difference between the sexes is one of kind or degree, or only of proportion, between the various mental and moral faculties, how this difference should be dealt with in education, whether women suffer physically from regular and sustained mental effort during the transition from girlhood to womanhood, or whether it does not rather steady the nervous system and preserve the due balance between the emotional and intellectual nature essential to

the sound mind in the sound body, what, in short, is the type of perfect womanhood and how it is to be developed, are questions waiting for impartial study, and on the right solution of which the future welfare of the race will largely depend. The last point to mention is the system of examinations, which practically governs our whole scholastic procedure. We require some scientific principle to decide what is the right system of examination, whether it shall test memory or intelligence, the knowledge of words or of ideas, of rules or of principles underlying those rules. Since an examination is now the inevitable portal to every professional career, it is not too much to say that the results it tests and rewards will be the only ones generally aimed at. It is not expected of schoolmasters and mistresses, and mothers of families, that they should master this vast range of knowledge or be ready with answers to all these questions. What is wanted is that they, like our practical navigators, should be furnished with the principles of a science they have not had to discover for themselves, and with charts to guide their general course, leaving to their individual acumen the adaptations and modifications required by special cirumstances.

The proofs of these charges against the present system, or want of system, in education are to be found in the Reports of the Royal Commissioners on Public Schools and Endowed Schools, of the Committee of Council on Education, of the various medical examining bodies, in the evidence of schoolmasters and mistresses, and in the facts of our social life. Great services have been rendered to the cause of scientific education by many writers and practical educators at home and abroad, in times past and present; but these services have not had their due meed of public recognition and acknowledgment, and the valuable materials supplied have not been coordinated into a body of science admitted into the recognized hierarchy of sciences, although education, as the application of all other sciences to the production of the highest of all results, may be boldly proclaimed the crowning science of all.

Sanitary Legislation and Organization: its Present State and Future Prospects. *By* THOMAS W. GRIMSHAW, *A.M., M.D.*

Although the parliamentary session which has just terminated has not been so eventful in sanitary legislation as many sanguine sanitarians anticipated, yet, with the small time at its disposal, the extreme hurry of public business, and the difficulties which a new Ministry had to deal with in a new House of Commons, a considerable advance has been made in sanitary legislation during the past session by the passing of the Public Health (Ireland) Act, the Public Health (Scotland) Act, the Sanitary Laws Amendment Act, the Vaccination Amendment Acts, and the Registration of Births and Deaths Amendment Act, besides the advantage likely to accrue from the Report of the Select Committee on the Adulteration Act of 1872, and the passing of the new standing orders with regard to the destruction of dwellings of the working classes for the construction of works for public companies.

The requirements of sanitary legislation appear to me to be as follows:—

I. A codification, consolidation, and amendment of existing laws.

II. Convenient areas for administration, with easily workable subdistricts.

III. Uniform authorities without clashing of jurisdiction.

IV. A complete executive organization.

V. Constant supervision by the central authority.

VI. Security for a certain amount of independence for the local officers from the local authorities.

I. Codification and amendment of sanitary law.

I believe sanitary law to be one of those subjects so technical, and the terms of which are susceptible of very considerable accuracy of definition, that it is eminently suited for codification.

Not only was sanitary legislation spasmodic, but generally undertaken under the influence of panic, either from a recently past, present, or impending epidemic. The first real attempt at systematic legislation was made in 1848. In 1866 was passed the Sanitary Act of 1866, which may be considered the first attempt at

a general measure of public health legislation. This Act was got up in a hurry to meet the cholera epidemic of 1865–66. The Act was permissive and nearly useless. It laid down useful principles, and must be looked upon as the backbone of future sanitary legislation. All these Acts were useless until the Public Health Act of 1872 was passed, which made action under the sanitary Acts compulsory on local authorities. This Act broke down almost completely. Now a similar Act has been passed for Ireland, but is vastly superior to its English prototype. After the foregoing statement it is scarcely necessary to prove that sanitary law requires codification and amendment. Mr. Michael, an English, and Mr. Furlong, an Irish barrister, agree in condemning the present state of sanitary law.

The Royal Sanitary Commission of 1867, in its Report, states that "the present fragmentary and confused sanitary legislation should be consolidated, and the administration of sanitary law should be made uniform, universal, and *imperative* throughout the kingdom." The amendments of sanitary law which should be introduced into any complete code are:—

1. General laws with regard to the construction of dwellings.—Houses at present may, in the majority of places, be built in any way the owner pleases, and the law concerning houses unfit for human habitation does not come into force unless the owner of the houses purposes that they shall be inhabited.

2. Amendment of the laws respecting food and drink.

3. General laws regarding markets and slaughter-houses.

4. Laws with regard to the keeping of animals to be used *as* food or in the production of food, such as would be specially applicable to dairy-yards, which are a great evil in most large towns. I believe, with regard to other matters, there is now law enough to remedy defects; and if the above additions were made, the present law slightly amended, and the whole codified, scarcely any thing more would be required.

II. Convenient areas of administration, with easily workable subdistricts.

The areas which suggest themselves in the first instance as suitable sanitary districts are those which are in use for other purposes, and this principle was at once adopted in all sanitary legislation. It is impossible to go into all the various kinds of subdivision of the different parts of the kingdom; but it is sufficient to state that for each important purpose a separate kind of division has been adopted, especially in England, less, however, in Scotland, and still less in Ireland. Two classes of existing local districts were selected, namely, urban districts and rural districts. In England the districts consist of the Metropolis-Boroughs, Improvement-Act Districts, Local-Government Districts, and Poor-Law Unions, each with its local governing body as its sanitary authority. In Scotland the districts are Towns under Town Councils, places under Police Commissioners, and parishes with parochial boards. In Ireland the districts are the city of Dublin, towns corporate, towns with populations over 6000 having town commissioners under General Acts, all towns under Local Acts and Poor-Law Unions, each with its local governing body as its sanitary authority.

The difficulties which arise from want of uniformity are:—

1. Conflict in the jurisdiction of the authorities.

2. A want of uniformity in their areas and population, most of them being too small for separate administration.

3. General irregularity in their form, many being long and narrow, and therefore unmanageable, and often laid out without any reference to the natural drainage of the country. How can all this be remedied? It seems to me that, by taking a sufficient number of these divisions, uniting them into an administrative district for all local purposes, and constituting the local authorities from the representatives of these, the difficulty would be got over.

If the English and Scotch systems of poor-law medical relief were assimilated to that of Ireland, the principle of the Irish Public Health Bill could be immediately made applicable to those countries, and thus one great difficulty solved.

III. Uniform authorities without clashing of jurisdiction.

The views I have stated regarding districts must, if accepted, decide to a great extent all other questions, especially those with reference to authorities. In a few instances large towns, say of over 30,000 inhabitants, should constitute separate

districts. The authorities of these should include, besides elected, a certain number of *ex officio* members, or members recommended by the central authorities.

IV. Complete executive organization.

This should consist of—

1. The Central Authority.
2. The Medical Advisers of the Central Authority.
3. Inspecting Medical Officers of Health.
4. The Superintendent Medical Officers of Health.
5. Local Medical Officers of Health.
6. Engineering Staff.
7. Inspectors of Nuisances.
8. Analysts.

1. The Central Authority is in England and Ireland at present, and should continue to be, the Local Government Board. In Scotland it is the Board of Supervision for the relief of the Poor and of Public Health, which might be better called the Local Government Board of Scotland. In order to make these boards efficient as central authorities for supervision of matters connected with public health, I consider that certain duties now attached to other departments should be transferred to these boards—namely, the supervision of lunatics and the inspection of factories, and the registration of births, deaths, and marriages, and a new department for the registration of disease. The Central Health Authority is the only department which requires immediately to utilize the statistics collected by the Registrars-General; and I would suggest that the Registrars-General departments should be amalgamated with the Local Government departments, and the Registrars-General become Local Government Commissioners.

2. The Medical Adviser of the Central Authority.—I consider the position occupied by this officer in Ireland is his proper position, and that the medical adviser in such important matters should always occupy a seat on the Board.

3. Inspecting Medical Officers of Health.—This title was proposed by my friend Mr. Furlong, and I consider it an extremely suitable one. It must be admitted that an efficient special department of experts exists in connexion with the English Local Government Board, namely, the medical department which is under the direction of Mr. Simon; but the inspectors (all eminent men) only exercise their functions under special circumstances, generally connected with outbreaks of disease. The duties, therefore, of this department do not so much tend to the prevention of disease (the object of sanitary legislation and organization) as to inquire into the cause of some disease which has already been allowed to produce fatal results. I would suggest that a staff of local government inspectors should be constantly employed, each with a special district assigned to him, these inspectors to be called Inspecting Medical Officers of Health. There would be considerable difficulty in selecting suitable districts; but I think this may be accomplished by taking as a basis the divisions adopted by the Registrars-General.

4. The Superintendent Medical Officers of Health.—These are the officers provided for by the Irish Act of 1874, and are, I believe, intended to superintend only public health operations in populous places, such as large towns, say towns of 30,000 inhabitants and upwards. Of such towns there are 130 in England, seven in Scotland, and four in Ireland, but with suburban districts added there must be several more in each country. I consider similar officers should be provided for towns in England, and they would correspond to the medical officers of health of urban sanitary districts.

5. Local Medical Officers of Health.—These should be, as provided in the Irish Act, the poor-law medical officers, each for his own district; but their employment is at present optional in England, and this has resulted in great confusion. The poor-law officers are manifestly the most suitable, as the very nature of their occupation brings them in contact with the first outbreaks of epidemics.

6. The Engineering Staff.—Every sanitary authority must have a surveyor in arge towns permanently employed, but in small places and rural districts employed as consultants only when required. There should also be engineering inspectors corresponding with the medical inspectors, but their districts might be much wider.

7. Inspectors of Nuisances.—These should correspond respectively with the superintendent medical officer of health and the local medical officer of health, and should be under the control of these officers.

Now, how are these officers to be appointed and paid? All the inspecting officers should be appointed and paid by the state. All the local officers should be appointed by the local authorities, but with the consent of the central authority, and should be paid partly by the local rates and partly by the state as at present, or (what I should prefer) the whole service for the United Kingdom should be made a public health *Civil Service* of the state.

8. Analysts.—The appointment of public analysts has rather fallen into disrepute of late; and no wonder, considering the curious nature of the appointments.

V. Constant supervision by the central authority.

It is scarcely necessary to write more upon this point, as the inspecting medical and engineering officers will secure this.

VI. Security for a certain amount of independence for the local officers from the local authorities.

This will, I think, be amply secured by the constant supervision and the arrangements for payment and appointment. If the service was made a State Civil Service, the independence would be complete. This security for independence is a matter of more importance than most people think. It may not unfrequently happen that the offender against sanitary law will be a member of the local authority.

On Postal Reform. *By* W. Hastings.

Reference made to the paper read at the Bradford Meeting proposing an immediate adoption of one penny as a sufficient rate for a single letter between any two post-offices, however distant, which have a regular uninterrupted communication. As one penny is sufficient where there is transit in addition to the service of two post-offices, one eighth of a penny should suffice for mere stamping, sorting, and delivery; and if this were combined with hourly deliveries from 8 A.M. till evening, a traffic which has now no existence, but which would be an immense boon to the public, would soon arise, and the lowness of the postage would draw into the post-office a host of printed matter, circulars, cards, and advertisements which are now almost invariably sent out by special messengers.

The plan of hourly delivery was adopted in 1766 in Edinburgh by a Mr. Peter Williamson, and was so successful that the post-office gave him a pension to give up his venture.

The success of omnibus traffic, which depends on frequency and punctuality, is a warrant, in the author's opinion, that if his plans were adopted with letters it would have a like success.

Reclamation and Sanification of the Pontine Marshes. *By* Dr. Henry MacCormac.

A multitude of publications have appeared on this important matter, among the rest Prony's "Marais Pontins" and Dr. Balestra's "Poche Parole sul Risanamento dell' Agro Romano" in the 'Archivio di Medicina,' Rome, 1873. If things go on as they are doing, observes Secchi in his 'Sulle Condizioni Igienice del Clima di Roma,' we need have little hesitation in prophecying that Rome must become an oasis in the midst of a pestiferous desert, the prey of desolation ("*preda della desolazione*"). The tracts variously termed Pontine Marshes (Maremma, Campagna, Agro Romano) extend some few hundred miles along the Italian shores, occasionally penetrating twenty miles into the interior, from Cecina in the north to Terracina in the south. The alluvium from the Apennines, in the course of ages, has formed apparently this low-lying, naturally fertile, but otherwise most insalubrious tract—once, Pliny states, occupied by more than thirty cities, but now lying waste and desolate. Even so recently as the fifteenth century it was comparatively populous; a few hired labourers and overseers, however, excepted, with the harvesters who come down from the hills, the district at present is deserted. Various Pontiffs,

preceded by more than one Roman Emperor, tried their hands at drainage; but the incessant civil and religious wars, with the absence of general simultaneous effort, defeated every attempt. A permanent staff of engineers, such as we find in Holland in connexion with the dykes, a well-digested plan of action, with unintermitted personal supervision, would all prove requisite. The antiquated Appian Way and railways excepted, no properly constructed roads traverse this vast region. There are no dwellings either; at least the poor labourers who reap the sparse crops in the season, when their sweltering day's toil is done, sleep absolutely without a roof over them in the open, and with little sustenance beyond a slice of water-melon and a crust. The Pontine Marshes are said to derive their name from Pometia, one of the perished cities. Roads and even canals appear to have been constructed so far back as the times of Appius Claudius, Julius Cæsar, Augustus Cæsar, Trajan, and subsequently by Popes Boniface, Martin, Leo, Sixtus, and Pius. The French also made some attempts; but, all these notwithstanding, the Pontine Marshes are Pontine Marshes still. The reclamation of the Agro Romano, as Dr. Balestra most justly insists, in point of canalization and subsequent culture ought to extend simultaneously to the whole of the implicated surfaces (*"all' intera campagna, assolutamente a tutti i terreni"*). No operations, however, at least in certain localities, ought to be conducted in July and August, as the paludal poison or malaria at such periods is simply homicidal. Periodical overflows of the Tiber should also be prevented. Such occurrences, as shown in the great recent increase of intermittents from the bursting of the banks of the Po, are greatly conducive to paludal disease. Raised tram- and causeways, in fact, ought to intersect the whole region. Canals extending to the sea, aided at their outlets when needful by the steam-engine, should carry off every particle of stagnant water. Salt water and fresh ought nowhere to be permitted to mix. Labourers should be safely housed in suitable localities, or, when season and position permitted and required, conveyed nightly to their homes on the hills. Steam-ploughs, steam-reapers, and steam-mowers, as far as possible, must be made to supersede human toil. And, lastly, I would have serried masses of the *Eucalyptus globulus, Helianthus* or sunflower, *Pistia stratiotes*, and others, as the editor of the 'Pabellon Medico' in May last urges, to extend along highways and around dwellings, in short every locality where human beings require protection from the baneful influence of marsh miasma (*"como preservador de las fiebras de acceso"*). The pine-trees generally and the various individuals of the natural order Myrtaceæ, indeed, seem highly antagonistic to malaria, qualities more or less appreciated in ancient as well as modern times. It is, in truth, almost incredible that nations should, at a vast outlay, keep playing at soldiers and sailors when, as in the case of the Italian Maremma and the watery expanses of Ireland, highly removable blights are permitted to eat into the very vitals of the community.

Reformatory and Industrial School System, its Evils and Dangers. By HANS M'MORDIE, *M.A.* (*Belfast*).

The author directed attention to the evils and dangers of the Reformatory and Industrial School system. The governing committee is a private and self-elected body and practically irresponsible. The tax-payers have no voice in the selection of the persons who control and distribute the funds. The Reformatory and Industrial Schools are prisons, for the inmates are deprived of personal liberty. The supervision exercised over them is inadequate. Our jails are subjected to the most regular and careful supervision. Voluntary associations should not be entrusted with the punishment of crime. The committees, moreover, are not bound to receive all whom the magistrate or judge may send. The cost of the system is enormously great, and in addition to its revenue from the public funds, it intrudes on the supplies intended for truly charitable institutions. Though the condition of destitution is that most prolific of physical imperfection, the schools will not receive the deformed child. The schools must pay, and therefore a selection is necessary. The system is competing unfairly with the artisan and trader. Some committees tender for orders; they being subsidized by the public funds can

undersell, and thus they tend to drive the legitimate trader and artisan from the market. The institutions are sectarian; they thus intensify religious bigotry—a fruitful source of great evils in our social system. The number of juvenile criminals is not decreasing. The system has failed to repress juvenile crime and to reform criminals. Its indirect moral effects are bad. It tempts the children of the poor to abandon honest labour and become inmates. It tends to destroy the feeling of parental responsibility. It induces parents to neglect their duties to their children so as to qualify them for the Industrial School or Reformatory. He suggested that the workhouse system (reformed in its present working) could by an easy extension take the place of the Reformatory and Industrial School. The tax-payer is represented on its board. The proceedings and accounts are subject to public control. It has buildings and a staff of officials in every union. It was devised to meet the claims of destitution, and is non-sectarian. It is much less costly, and the rights of the state are protected by the Local Government Board.

On the Future of the United States. By G. W. Norman, *F.S.S.*

On the Cause of Insolvency in Life-Insurance Companies, and the best Means of detecting, exposing, and preventing it. By T. B. Sprague, *M.A., F.S.S.*

A Scheme for the Technical Education of those interested in Land. By the Rev. William Watson Wood, *Wickham Market, Suffolk.*

The writer of this paper drew the attention of the Section to the want of technical knowledge displayed by those most interested in the cultivation of land, whether as landlords or tenants, and proposed a plan by which this necessary knowledge might be obtained. After remarking upon the unintelligent cultivation of land which was made to produce only two and a half quarters per acre, whilst land of the same description, in soil and subsoil, produced five or six quarters of the same cereals, and on grass lands showed even a greater disparity of production, he cited instances within his own experience of improvements actually made on farms of different soils and situations.

1st. A light-land park in 1848 produced scarcely grass enough for two cows and twenty sheep, and was let at 12*s.* 6*d.* per acre. By a very small outlay the amount of stock fed was trebled, and the land has been let since for £2 5*s.* per acre.

2nd. On poor heavy-land pasture, almost valueless and growing the worst kinds of grasses only, by drainage, manuring, and sowing the better kinds of grass seeds, the produce in 1872 was estimated at £100 on nine acres. The purchase of manure, he remarked, would be needless if the right artificial manures were used on the arable lands at the right time in fair quantity, and suitable to the wants of the different cereals for which it was applied, three and a half loads of straw per acre, which might easily be grown on such lands, allowing a good margin for the manuring of pastures, if mixed with artificial food, and thus made into manure of a certain strength.

The third instance he adduced was that of a park that would scarcely keep a herd of deer, and which, by the use of underground irrigation, returned £40 per acre in 1870. He then proceeded to remark that whilst England justly claimed pre-eminence for her breeds of horses and cattle, yet the great majority of these were bred regardless of those points which would add to their utility and beauty. "Drive," he writes, "a few miles in any direction from visiting the most famous breeds, and how many flocks or herds do you find possessing any thing approaching their qualities? It is no exaggeration to say that many persons might suppose, from observation of the stud or stock-yard, that those who send stock to them were intent upon perpetuating their imperfections. There is no reason, except unintelligent management and cultivation, why we should not have horses and meat both better and cheaper." The attention of the Section was next invited to the number of unintelligent farmers intermixed with others who farmed unin-

telligently and injured the farms, the community, and themselves. "A close observation of many years," said the writer, "during which it has been my custom to drive long distances for the express purpose of investigting this matter, convinces me that the proportion of ill-cultivated land in England is seriously large, and the loss to the nation and to individuals is immense. Men will take farms, and landlords will accept them as tenants, who scarcely understand the systems in vogue, nor the modern discoveries and inventions which would increase the fertility of their land and enhance its value: the consequences are obvious, the land, improperly cultivated, deteriorates in value, a double blow is death at the pocket of the occupier and at the condition of the farm, and too often it takes years to recoup the one and to restore the other."

The scheme "for the technical education of those interested in land" was then introduced. The main points were the combination of ordinary education with the gradual acquisition of agricultural knowledge, the slow process of vegetable growth admitting of gradual instruction in the raising and treatment of plants and cereals, especial stress being laid upon the fact that "life at a public school or at a university unfits young men, more or less, for the acquirement of such knowledge, their tastes and inclinations interfering in many cases with the necessary work to be done and the necessary observation to be given ere a man can really understand the requirements of plants and animals and the manipulation (which on heavy land is extremely delicate and important) of varying soils.

Assuming that the desirability of acquiring this knowledge was conceded, the writer then proposed that it should be imparted to students, from time to time, in such a manner as not to interfere with ordinary scholastic teaching, the only objection appearing to be the expense of an extra teacher, whose whole time should be given to this branch of education. In this manner, it was the writer's opinion, that it was possible to make young men "brilliant scholars and intelligent practical farmers at the same time," conferring upon them information most useful to members of Parliament, magistrates, and country gentlemen, and "enabling them to comprehend the wants and feelings of their tenants and neighbours, and thus investing them with a certain moral power which without this knowledge they could not possess in so high a degree."

MECHANICAL SCIENCE.

Address by Prof. JAMES THOMSON, *C.E., F.R.S.E., President of the Section.*

FOR a number of years past it has been customary, in this and other sections of the British Association for the Advancement of Science, that the President should give an introductory address at the opening of each new session. In compliance with that usage, I propose now to offer to you a few brief remarks on various subjects of Mechanical Science and Practice. These subjects have not been chosen on any systematic plan. I have not aimed at bringing under review the whole or any large number of the most important subjects at present worthy of special notice in Engineering or in Mechanics generally. I intend merely to speak of a few matters which have happened to come under my notice, or have engaged my attention, and which appear to me to be interesting through their novelty or through their important progress in recent times, or to merit attention as subjects in which amendment and future progress are to be desired.

In Railway Engineering, one of the most important topics for consideration, as it appears to me, is that which relates to the abatement of dangers in the conducting of the traffic. The traffic of many of our old railways has become enormously increased in recent years. With the construction of new lines the numbers of junctions, stations, and sidings have been greatly increased; and each of these entails some attendant dangers. As a natural consequence of the increased traffic on

old railways, the additional traffic on new lines, and the increased complexity of the railway system as a whole, there have been during recent years more numerous accidents than in the earlier times of railways. It is to be recollected, however, that with a greater number of people travelling daily, more numerous accidents might be expected, and that their increased frequency, on the whole, does not necessarily indicate increased danger to the individual traveller. Referring to the Statistics of Railway Accidents published by the Board of Trade in Captain Tyler's Report for the year 1873, I find, for various periods during the last 27 years, throughout the United Kingdom, the proportion of passengers killed from all causes beyond their own control, to the number of passengers carried, to have been, in round numbers:—

Proportion of number killed to number carried in the three years, 1847, 1848, and 1849	1 in 4,782,000
In the four years, 1856, 1857, 1858, and 1859	1 in 8,708,000
In the four years, 1866, 1867, 1868, and 1869	1 in 12,941,000
In the three years, 1870, 1871, and 1872	1 in 11,124,000
And in the single year 1873	1 in 11,381,000

It is thus gratifying to observe that, in spite of the increased risks naturally tending to arise through the increased and more crowded traffic, and the more complicated connexions of lines, the danger to the individual traveller is now less than half what it was 26 years ago; at least this result is indicated, in so far as we can judge, from the statistics of deaths of passengers from causes beyond their own control. That the conducting of the traffic of railways still involves hazards far from inconsiderable, and that we have much to wish for towards abatement of dangers of numerous kinds, is proved by the fact that, during the single year 1873, there have been killed of the officers and servants of the railway companies in the United Kingdom 1 out of every 323; so that, at this rate, extended through a period of, for example, 20 years' service, there would be 1 out of every 16 of the officers and servants killed.

These deaths of officers and servants are not to be supposed to be caused in any large proportion by collisions and by other accidents to trains in rapid motion. The great majority of them arise in shunting and other operations at stations and along the lines, and occur in numerous ways not beyond the control of the individuals themselves. In respect to the passengers, too, it ought to be known and distinctly recollected, that although collisions and other violent accidents to trains in rapid motion, together with other accidents beyond the control of the individuals, usually cause by far the deepest impression on the public mind, yet the numbers of these fatal accidents are small in comparison to others arising to passengers from causes more or less within their own control. For instance, it may be noticed that in last year, the year 1873, while the deaths of passengers arising from all causes beyond their own control, in the United Kingdom, were only 40 in number, there were four times as many killed, namely 160, in other ways; and of these there were so many as 62 killed in the simple way of their falling between carriages and platforms.

In respect to the conducting of the traffic of the trains in motion, it appears to me, on the whole, that when we consider the vast complexity of the operations involved in working many of our ramified and crowded railways, and when we consider the indefinitely numerous things which must individually be in proper order for their duty, and must be properly worked in due harmony by men far away from one another, some stationed on the land, and others rushing along on the engines or trains, the wonder is, not that we should have numerous accidents, but that accidents should not be of far more frequent occurrence. There can be no doubt, however, but that of the accidents which do occur many arise from causes of kinds more or less preventible according to the greater or less degree in which due precautions may be adopted.

Gradually, during a period of twenty or thirty years past, a very fine system of watching, signalling, and otherwise arranging for the safety of trains has been contrived and very generally introduced along our principal lines of railway. In saying this, I allude chiefly to the block system of working railways, with the aid

of telegraphic signals and interlocking mechanisms for the working of the points and signals.

In former times it was customary to allow a certain number of minutes to elapse after a train passed any station, or junction, or level crossing, or other point where a servant of the company was stationed, before the succeeding train was allowed to pass the same place. Thus at numerous points along the line a time interval was preserved between successive trains. It was quite possible, however, that the foremost of the two trains, after passing any of these places where signals were given, might become disabled, or might otherwise be made to go slowly, and that the following train might overtake it, and come into violent collision with it from behind. In order to provide against the occurrence of such accidents, a system was introduced called the *Block System*; and its main principle consists in dividing the line into suitable lengths, each of which is called *a block section,* and allowing no engine or train to enter a block section until the previous engine or train has quitted that portion of the line. In this way a space interval of at least the length of a block section is preserved between the two trains at the moment of the later train's passing each place for signalling; and the risk of this space interval becoming dangerously small by negligence or other accidental circumstances, as the later train approaches the next place for signalling, is almost entirely avoided.

Further, at each signalling-station, the various levers or handles for working the points, and those for working the semaphore signals for guiding the engine-drivers, instead of being, as was formerly the case, scattered about in various situations adjacent to the signalling-station, and worked often some by one man and some by another, without sufficient mutual understanding and without due harmony of action, are now usually all brought together into one apartment called the signal-cabin. This cabin, like a watch-tower, is usually elevated considerably above the ground, and is formed with ample windows or glass sides, so as to afford good views of the railway to the man who works the levers for the semaphores and points, and who transmits by electricity signals to the next cabins on both sides of his own, and, when necessary, to other stations along the line of railway.

The interlocking of the mechanisms for working the points and for working the semaphores, which, by the signals they show, control the engine-drivers, consists in having the levers by which the pointsman works these points and signals so connected that the man in charge cannot, or scarcely can, put one into a position which would endanger a train without his having previously the necessary danger-signal or signals standing so as to warn the engine-driver against approaching too near to the place of danger.

The latest important step in the development and application of the block system is one which has just now been made in Scotland, on the Caledonian Railway. Before explaining its principle, I have first to mention that a semaphore arm raised to the horizontal position is the established danger-signal, or signal for debarring an engine-driver from going past the place where the signal is given. Now the ordinary practice has been, and still is, to keep the semaphore arm down from that level position, and so to leave the line open for trains to pass, except when the line is blocked by a train or other source of danger on the block section in front of that semaphore, and only to raise the semaphore arm exceptionally as a signal of danger in front. The new change, or improvement, now made on the Caledonian Railway consists mainly in arranging that along a line of railway the semaphore arms are to be regularly and ordinarily kept up in the horizontal position for prohibiting the passage of any train, and that each is only to be put down when an approaching train is, by an electric signal from the cabin behind, announced to the man in charge of that semaphore as having entered on the block section behind, and when, further, that man has, by an electric signal sent forward to the next cabin in advance, inquired whether the section in advance of his own cabin is clear, and has received in return an electrical signal meaning "*The line is clear; you may put down your debarring signal, and let the train pass your cabin.*" The main effect of this is that along a line of railway the signals are to be regularly and ordinarily standing up in the debarring position against allowing any train to pass; but that just as each train approaches, and usually before it has come in sight, they go down almost as if by magic, and so open the way in front of the train, if the line is ascer-

tained to be duly safe in front; and that immediately on the passage of the train they go up again, and, by remaining up, keep the road closed against any engine or train whose approach has not been duly announced in advance so as to be known at the first and second cabins in front of it and kept closed, unless the entire block section between those two cabins is known to have been left clear by the last preceding engine or train having quitted it, and is sufficiently presumed not to have met with any other obstruction, by shunting of carriages or waggons, or by accident, or in any other way.

This new arrangement*, which appears to be a very important improvement, has already been brought into action with success on several sections of the Caledonian Railway; and it is being extended as rapidly as possible on the lines of the Caledonian Company, where the ordinary mode of working the block system has hitherto been adopted.

The mechanisms and arrangements I have now briefly mentioned are only a portion of the numerous contrivances in use for abatement of danger in railway-traffic. It is to be understood that by no mechanisms whatever can perfect immunity from accidents be expected. The mechanisms are liable to break or to go wrong. They must be worked by men, and the men are liable to make mistakes or failures. We shall continue to have accidents; but if we cannot do away with every danger, that is no reason why we should not abate as many dangers as we can.

Within the past twenty years very remarkable progress has been made in steam-navigation generally, and more especially, I would say, in oceanic steam-navigation. In this we meet with the realization of great practical results from the combination of improved mechanical appliances and of physical processes depending on a more advanced knowledge of thermodynamic science.

The progress in oceanic steam-navigation is due mainly to the introduction jointly of the screw propeller, the compound engine, steam-jacketing of the cylinders, superheated steam, and the surface-condenser.

The screw propeller, in its original struggle for existence, when it came into competition with its more fully developed rival, the paddle-wheel, met with favouring circumstances in the want then strongly felt of means suitable for giving a small auxiliary steam-power to ships arranged for being chiefly propelled by sails. For the accomplishment of this end the paddle-wheel was ill suited; and so the screw propeller got a good beginning for use on long oceanic voyages. Afterwards, in the course of years, there followed a long series of new inventions and improved designs in the adaptation of the steam-engine for working advantageously with the new propeller; and it has resulted that now, instead of the screw being used as an auxiliary to the sails, the sails are more commonly provided as auxiliaries to the screw. For long oceanic voyages it became very important or essential to get better economy in the consumption of fuel. In order to economize fuel, high-pres-

* [Since the delivery of this address, a remark by the editor of 'Engineering,' in the issue of that Journal for August 28, 1874, has come under my notice, in which he denies the supposed novelty of the system of signalling here described as newly introduced on the Caledonian Railway. He states that the system described has been in use for many years past on several railways, and that, amongst others, the Metropolitan Railway has never been worked upon any other system. Also he says that on a portion of the Great Eastern (then the Eastern Counties Railway) the system was in use upwards of twenty years ago. On the other hand, I learn from officers of the Caledonian Railway engaged in carrying out the alteration of system on the lines of the Caledonian Company, that they think the system as introduced on their railway has still much of novelty in comparison with any thing previously done on any line extending over long distances in the country, and that though the Metropolitan Railway be worked on a system similar in some respects to that which they are introducing, yet the whole circumstances of that urban railway are so different from those of railways extending through the country, as to leave the introduction of the system here described on an ordinary railway, such as the Caledonian, still to be regarded as a change presenting important features of novelty in a practical point of view.

Having now mentioned these statements, I prefer to leave any further discussion of the distinctions of different systems which have been or are in use, and of exact points of novelty in their introduction, to those who may be in possession of fuller evidence on the subject than what has hitherto been obtained by me.—James Thomson, *November* 1874.]

sure steam, with a high degree of expansion and with condensation, was necessary. This led to the practical adaptation for the propulsion of vessels of the compound engine, an old invention which originated with Hornblower in the latter part of last century, and was afterwards further developed by Wolff. The high degrees of expansion could not be advantageously used in cylinders heated only by the ordinary supply of steam admitted to them for driving the piston; and more especially when that steam was boiled off directly from water without the introduction of additional heat to it after its evaporation. The knowledge of this, which was derived through important advances made in thermodynamic science, led to the introduction into ordinary use in steam-navigation of steam-jacketed cylinders, and to the ordinary use also of superheated steam. With increased efforts towards economy of space in the hold of the ship, which became the more essential when very long voyages were to be undertaken, and with the new requirement of greatly increased pressure in the steam, the old marine boilers, with their flues of riveted plates, were superseded by tubular boilers more compact in their dimensions and better adapted for resisting the high pressure of the steam. In connexion with these various changes the old difficulty of the growth of stony incrustations in the boilers became aggravated rather than in any way diminished. As the only available remedy for this, there ensued the practical development and the very general introduction of the previously known, but scarcely at all used, principle of surface-condensation instead of condensation by injection. A supply of distilled water from the condenser is thus maintained for feeding the boilers, and incrustations are avoided. The consumption of coal is often found now to be reduced to about 2 lbs. per indicated horse-power per hour, from having been 4 or 5 lbs. in good engines in times previous to about twenty years ago.

Before the times of ocean telegraph-cables very little had been done in deep-sea sounding; but when the laying of ocean cables came first to be contemplated, and when it came afterwards to be realized, the obtaining of numerous soundings became a matter of essential practical importance. In the ordinary practice of deep-sea sounding, as carried on both before and since the times of ocean telegraph-cables, until a year or two ago, a hempen rope or cord was used as the sounding-line, and a very heavy sinker, usually weighing from two to four hundredweight, was required to draw down the hempen line with sufficient speed, because the frictional resistance of the water to that large and rough line moving at any suitable speed was very great. The sinker could not be brought up again from great depths; and arrangements were provided, by means of a kind of trigger-apparatus, so that when the bottom was reached the sinker was detached from the line, and was left lying lost on the bottom, the line being drawn up without the sinker, but with only a tube of no great weight, adapted for receiving and carrying away a specimen of the bottom. For the operation of drawing up the hempen line with this tube attached, steam-power has been ordinarily used, and practically must be regarded as necessary.

A great improvement has, within the last two or three years, been devised and practically developed by Sir William Thomson. Instead of using a hempen sounding-line, or a cord of any kind, he uses a single steel wire of the kind manufactured as pianoforte wire. He has devised a new machine for letting down into the sea the wire with its sinker, and for bringing both the wire and the sinker up again when the bottom has been reached. With his apparatus, in its earliest arrangement, and before it had arrived at its present advanced condition of improvement, he sounded, in June 1872, in the Bay of Biscay, in a depth of 2700 fathoms, or a little more than three miles, and brought up again his sinker of 30 lbs. weight after it had touched the bottom, and brought up also an abundant specimen of ooze from the bottom, in a suitably arranged tube attached at the lower end of the sinker.

An important feature in his machine consists in a friction-brake arrangement, by which an exactly adjusted resistance can be applied to the drum or pulley which holds the wire coiled round its circumference, and which, on being allowed to revolve, lets the wire run off it down into the sea. The resistance is adjusted so as to be always less than enough to bear up the weight of the lead or iron sinker, together with the weight of the suspending wire, and more than enough to

bear up the weight of the wire alone. Thus it results that the arrival of the sinker at the bottom is indicated very exactly on board the ship by the sudden cessation of the revolving motion of the drum from which the wire was unrolling.

Another novel feature of great importance consists in the introduction of an additional hauling-up drum or pulley, arranged to act as an auxiliary to the main drum during the hauling-up process. The auxiliary drum has the wire passed once or twice round its circumference at the time of hauling up, and is turned by men so as to give to the wire extending from it into the sea most of the pull requisite for drawing it up out of the sea, and it passes the wire forward to the main drum, there to be rolled in coils relieved from the severe pull of the wire and sinker hanging in the water. Thus the main drum is saved from being crushed or crumpled by the excessive inward pressure which would result from two or three thousand coils of very tight wire, if that drum unaided were required to do the whole work of hauling up the wire and sinker.

The wire, though exposed to the sea-water, is preserved against rust by being kept constantly, when out of use, either immersed in or moistened with caustic soda. The fact that steel and iron may be preserved from rust by alkali is well known to chemists, and is considered to result from the effect of the alkali in neutralizing the carbonic acid contained in the water, as the carbonic acid appears to be the chief cause of the rusting of steel and iron.

This new method of sounding, depending on the use of pianoforte wire, was first publicly explained by Sir Wm. Thomson in the Mechanical Section of the British Association at the Brighton Meeting two years ago; and in the interval which has since elapsed it has come rapidly into important practical use.

I have to-day already brought under your notice a system of elaborately contrived and extensively practised methods of signalling and otherwise arranging for the safety of trains in motion on railways. These methods, in the aggregate, as we have them at present, may be looked on as the result of a gradual development, which, through design and intelligent selection, has been taking place during the last twenty or thirty years or more. In contrast with this I have now to mention a reform towards abatement of dangers at sea, which at present is only in an incipient stage of its practical application, but which, I am sure, must soon grow into one of the important reforms of the future. I refer to the provision of means whereby every important lighthouse shall, as soon as it is descried, not only make known to the navigator that a light is visible, but also that it shall give him the much more important information of what light it is,—that, in fact, it shall distinguish itself to him from all other lights either stationed on land or carried by ships out at sea. The rendering of lighthouses each readily distinguishable from every other light by rapid timed occultations was urged on public attention by Charles Babbage about twenty or twenty-three ago, in connexion with a like proposal of his for telegraphic signalling by occulting lights. His admirable idea, however, so far as it related to the distinguishing of lighthouses, has unhappily been left almost entirely neglected until quite recently. Although I say it was almost entirely neglected, yet very important steps in the direction of the object proposed were taken many years ago by Messrs. Stevenson, Engineers to the Commissioners of Northern Lights; and the flashing and intermittent lights introduced by them, and now used, although too sparingly, in various parts of the world, constituted a very great improvement in respect to distinctiveness. The first practical introduction of an intermittent extinction of a gas-light, which is a method now likely to become fruitful in important applications with further developments, was made many years ago by Mr. Wilson at Troon; and an admirable application of this plan by the Messrs. Stevenson to carry out the principle of rapid signalling is to be seen in the Ardrossan Harbour light, which is alternately visible for two seconds, and then for two seconds is so nearly extinguished as to be invisible. The whole period—four seconds—is, I suppose, the shortest of any lighthouse in the world. This light fulfils the condition of being known to be the light which it is within five or ten seconds of its being first perceived; and thus, in respect to distinctiveness, I trust that I may, without mistake, say it is the best light in the world. Mr. John Wigham has succeeded in constructing large burners for the combustion of gas in lighthouses in general, including those of the first order, and embracing both fixed lights and

revolving lights. He has also, in both these cases, applied with the most striking success the principle of occultation. Dr. Tyndall, in his Reports to the Board of Trade, has dwelt frequently and emphatically on the ease with which gas lends itself to the individualization of lights. By its application he affirms that, by simple arrangements, it would be possible to make every lighthouse declare its own name. Within about the last two or three years, the subject has been taken up energetically by Sir William Thomson. He has become strongly impressed with the enormous importance of the object in question. He has perseveringly laboured in making trials in various ways, both by the method of partially extinguishing gas-flames and by the method of revolving screens; and I have pleasure in stating that, as a result of his efforts, a self-signalling apparatus is now constructed for the Belfast Harbour Commissioners, who are preparing to bring it into immediate use at the screw-pile lighthouse, at the entrance of the harbour of Belfast. I shall not now enter on any description of this arrangement, as I understand that the apparatus, which has already been temporarily erected for trial in the lighthouse, and has shown good results, is to be exhibited and explained to this section by Mr. Bottomley, who, as a member of the Board of Harbour Commissioners, has taken an active part in the promotion of the undertaking.

I wish next to make mention of the very remarkable works at present in progress in the Harbour of Dublin, under the designs and under the charge of Mr. Bindon Stoney. In order to form quay walls with their foundations necessarily deep under water, he constructs on land gigantic blocks of artificial stone, or, as we may say, of concrete masonry, each of which is about 350 tons in weight, and which are accurately formed to a required shape. After the solidification of the concrete, he carries them away, and deposits them on an accurately levelled bottom of the sea, so that they fit closely together, and form so much of the quay wall in height as to reach above the low-tide level, and so as to allow of the completion of the wall above by building in the usual manner by tidal work, and to allow of the whole structure being carried out without the use of coffer-dams. These operations are on a scale of magnitude far surpassing any thing done before in the construction and moving of artificial stone blocks. They are carried out with machinery and other appliances for the removal and the placing of the blocks, and for other requirements of the undertaking, which are remarkable for boldness of conception and ingenuity of contrivance. The new methods of construction devised and applied in these works by Mr. Stoney are recognized as being admirably suited for the local circumstances of the site of the works in the Harbour of Dublin, and their various arrangements form a very important extension of the methods of construction available to engineers for river- and harbour-works.

While progress has been made with gigantic strides in many directions in engineering and in mechanics generally, while railways, steamboats, and electric telegraphs have extended their wonders to the most distant parts of the world, and while trade, with these aids, is bringing to our shores the produce even of the most distant places to add to our comforts and our luxuries, yet, when we come to look to our homes, to the places where most of our population have to spend nearly the whole of their lives, I think we must find with regret that, in matters pertaining to the salubrity and general amenities of our towns and houses as places for residence, due progress in improvement has not been made. Our house-drainage arrangements are habitually disgracefully bad; and this I proclaim emphatically, alike in reference to the houses of the rich and the poor. We have got, since the early part of the present century, the benefits of the light of gas in our apartments; but we allow the pernicious products of combustion to gather in large quantities in the air we have to breathe; and in winter evenings we live with our heads in heated and vitiated air, while our feet are ventilated with a current of fresh, cold air, gliding along the floor towards the fireplace to be drawn uselessly up the chimney. A very few people have commenced to provide chimneys or flues to carry away the fumes of their more important gas-lights, in like manner as we have chimneys for our ordinary fires. In mentioning this, however, as a suggestion of the course in which improvement ought to advance, I feel bound to offer a few words of caution against the introduction of flue-pipes for the gas-flames rashly, in such ways as to bring danger of their setting fire to the house.

People have a strong tendency to require that such things as these should be concealed from view. In this case, however, special care should be taken against rashly placing them among the woodwork between the ceiling of the apartment and the floor of the room above, or otherwise placing them in unsafe proximity to combustible materials. In many cases it would be better to place the flue exposed to view underneath the ceiling, and, by introducing some accompanying ornamentation, to let the flue be regarded as a beneficent object not unpleasing to the eye.

The atmosphere of our large towns, where people live by hundreds of thousands all the year round, is not yet guarded against needless pollution by smoke, jealously, as it ought to be. Many of the wealthier inhabitants take refuge in living in the country or in the suburbs of the town, as far away as they can from the most densely built and most smoky districts; but the great masses of the people, including many of all ranks, must live near their work, and for them, at least, greater exertions are due than have yet been made towards maintaining and improving the salubrity and the amenities of our towns. As to the abatement or prevention of smoke from the furnaces of steam-engines, the main requisites have long been very well known; but sufficient energy and determination have not yet been manifested towards securing their due application in practice. In too many cases futile plans have been tried, and on being soon abandoned have left a strong impression against the trying of more experiments; and this may account in part for the introduction of real improvements having been so slow. Smoke occurs when fresh coal is thrown suddenly, in too large quantity at once, on a hot fire. By extreme care a fireman may throw coal into his furnace so gradually as to make very little smoke; but mechanical arrangements for introducing constantly and uniformly the new supply of fresh coal have been devised, and several of these have been such as to reduce the smoke emitted to almost nothing. I have seen in the neighbourhood of Glasgow, at a large manufacturing establishment at Thornliebank, one method which is applied to about thirty ordinary 40 horse-power boilers, in which upwards of 100 tons of coal are daily burned, and from the chimneys of which not more smoke is emitted than from many a kitchen fire. This method is under the patent of Messrs. Vicars, of Liverpool, and it seems to work very well. It has been about two years in work there. It was introduced at a time when coal was exceedingly high in price, as much to effect economy in fuel as to prevent smoke; and although the first cost was somewhere about £130 per boiler, the proprietor considers himself to be already more than recouped for his outlay, as a saving of fully 12 per cent. in the fuel consumed was effected. At the same works I have also seen in operation the method of Messrs. Haworth and Horsfall, of Todmorden, which has, I am told, in certain circumstances, some advantages over the other. In this, as in the other, the coal is fed in uniformly by mechanical arrangements. The mechanism is different in the two cases, but the result in the motion communicated to the coals is very much alike in both. The bed of coal, which is gradually supplied in front, is caused to travel along the bars towards the inner end of the furnace, and the combustion proceeds in a very uniform manner in conditions highly favourable to economy of fuel, and without the emission of almost any visible smoke.

These two methods I have mentioned because they appear both to work very successfully in practice, while they both bring into effect the principle of action of the fuel which has long appeared to me to be the best that can be adopted for ordinary cases of steam-engine boilers.

Having now occupied, I think, enough of your time, I will conclude. I have endeavoured to select out of the wide range of subjects which fall within the scope of the Mechanical Section of the British Association a few which have come more particularly under my own notice, and on which I thought it was in my power to give intelligence that might be interesting as to past progress, and suggestions that might be useful towards extension of improvements in the future.

Compensating Apparatus for Distant Signal-wires of Railways. *By* G. W. Beynon.

Hitherto the old methods of the screw connexion or the ratchet-wheel have generally been employed as the only means of adjusting the wires of distant signals. At the commencement of this year the author invented this apparatus, which self-regulates and adjusts automatically the wires of signals, and which combines extreme simplicity and non-liability to get out of order with cheapness in manufacture. It consists in the use of a flat iron bar (the proportion of its depth to thickness being about 3 to 1) running upon its edge between grooved rollers contained in cast-iron brackets. To the front end is fastened the wire to the signal, and to the other is attached a chain, having a weight at the end sufficient to keep the wire in a state of tension. Upon this bar slides a frame containing two clutch-blocks. So long as this frame remains at 90° Fahr., the bar is free to move backwards or forwards between its rollers, as expansion or contraction may require; but when pulled so as to decrease the angle, the blocks seize the bar and draw it through its rollers a sufficient distance to efficiently work the signal. This machine has been at work for nearly eight months upon a signal distant five eighths of a mile, situated at the West Junction box, Reading, Great Western Railway. Ever since it has thoroughly fulfilled its object, and given the greatest satisfaction. Two machines have also been applied and have been at work for some time on two signals (semaphore and disk and cross-bar signals) five eighths of a mile distant each at East box, Reading Station, and have also given every satisfaction. The apparatus is unaffected by the weather, and can be relied on thoroughly; it is so contrived that no mischievous interference with the wire can take place whilst the signal is pulled over in either position.

On the Eclipsing-Apparatus constructed for the Lighthouse on the Holywood Bank, in Belfast Lough. *By* William Bottomley.

The main purposes for which lighthouses are erected are to mark the presence of dangers, either of rocks or sandbanks, which are to be avoided by ships, and to serve as guides for navigation. To attain these objects it is absolutely necessary that the light exhibited shall be easily and certainly recognized as being that of a particular lighthouse in a certain position, and no other. The mode at present in use for distinguishing lighthouses from each other is to have some variety in the lights exhibited; and the Admiralty charts mark the different lighthouses according to one or other of six different descriptions:—1. Fixed or steady; 2. Revolving; 3. Flashing; 4. Fixed and flashing; 5. Intermittent; 6. Alternate. A large majority of the lights on the coast are fixed, a considerable number are revolving, and out of 514 in the list corrected to January 1871, only 29 belong to the other four descriptions.

It must be evident that such a mode of distinguishing lighthouses is extremely imperfect. Fixed lights, though usually brilliant, are at a distance, and in foggy weather undistinguishable from shore- or ship-lights near at hand; and, notwithstanding the greatest care, one lighthouse may be mistaken for another. Revolving or flashing lights might possibly be distinguished by their periods, if those periods were regularly kept; but observations of such periods require an accuracy difficult to be attained at all times, and impossible in the trying circumstances in which vessels often approach a coast.

In order, under present arrangements, to make out with certainty what any observed light is, it is necessary that the master of the vessel shall first ascertain the position of his own ship. In many cases this cannot be done even in short voyages; but after a long voyage, and with few opportunities of making correct observations, errors of many miles may occur on a ship's reckoning. Every year the accounts of shipwrecks show the fatal results arising from the mistake of one light for another light many miles away. The signal which, properly interpreted, should have preserved the mariner from danger, becomes the false guide which lures him to destruction.

If, however, we had the means of causing each lighthouse to exhibit constantly

a light of such a character as could not possibly be mistaken for any othei lighthouse, for any ship's light, or for an ordinary shore-light, the master of the vessel would not only at once recognize it as being a particular lighthouse, but would be able at the same time to correct any error he had made in regard to his own position, and be able to proceed with confidence on his voyage.

Such a plan was proposed by Charles Babbage, and actually exhibited in the Exhibition of 1851. It was officially communicated by him to all the great maritime governments, and was elaborately described by him in a letter to the 'Times' of the 16th July, 1855.

For many years the suggested individualization of lighthouses remained unheeded by the public and neglected by the lighthouse authorities; but during the last few years the matter has attracted the attention of some men of scientific eminence, who, thoroughly convinced of the important benefits which would result from its universal adoption, are able to carry out the practical details required for putting it into operation, and whose character and position entitle them to press their convictions on the Government. The author referred especially to Mr. Stevenson, the engineer to the Northern Lights Commission, and to Dr. Tyndall, the scientific adviser of the Board of Trade and the distinguished President of the British Association.

A modification and improvement of Babbage's plan has been lately published by Sir William Thomson, who proposes that each lighthouse shall exhibit from sunset to sunrise a certain definite series of eclipses, representing one of the letters of what is known in telegraphy as the Morse alphabet. The Harbour Commissioners of Belfast, impressed with the great value and importance of the plan, adopted it for an improvement of the light on the Holywood Bank, which at present is a fixed red light liable to be mistaken for the red (or port) light of a vessel; and the apparatus exhibited to the Section was designed for the purpose by Sir William Thomson, and constructed by Mr. James White, of Glasgow, for the Commissioners. It consists of a horizontal ring of brass revolving on three vertical wheels or rollers, and it is kept in its place by three light horizontal wheels. One of the wheels on which the horizontal ring rests is kept in motion by a descending weight and a train of wheels, and the motion is regulated by a centrifugal friction-governor, which gives ample steadiness and regularity of speed. The horizontal ring carries three eclipsing-screens, the weight of which is counterbalanced by a piece of iron on the opposite side of the ring. The screens are at present arranged to give two short eclipses and one longer eclipse, corresponding to the letter U of the Morse alphabet. A complete revolution occupies eleven seconds, of which six seconds is the period of uninterrupted white light, and five seconds of eclipses with the intervening intervals of light. An alteration of the number and position of the screws enables us to form any letter of the alphabet that may be desired.

An experimental trial has been made of the apparatus on the lighthouse with very satisfactory results. In the course of a few weeks it will be in permanent operation; and the author ventured to express the belief that the success of the plan will keep public attention directed to the simple means of rectifying the defects of our present lighthouse system, and, in connexion with what is doing elsewhere, cause the adoption of it, or similar means of distinguishing lighthouses, along the coasts of the United Kingdom.

On the Differentiating Waste-water Meter.
By GEORGE F. DEACON, *M.Inst.C.E.*

The author explained that this instrument had been designed for the purpose of ascertaining the locality of waste of water due to leakages from pipes and fittings. It consists essentially in a vertical hollow truncated cone of brass, to the upper and smaller end of which the water from any service main is led, and from the lower end of which it passes to the district supplied by that main. Within the hollow cone, and equal in diameter to its upper end, is a horizontal metal disk, having on its upper side a rigid central stem by which it is hung from a German-silver wire passing through a lignum-vitæ bush to a dry chamber above, where it is connected with guide-wheels and with a gut-band passing over a pulley, on the other side of

which the gut-band is attached to a weight of fixed amount, which, when no water is passing, maintains the disk at the top of the cone.

Water being caused to flow through the cone, the disk will obviously move to a level at which the counterbalance weight is exactly balanced by the excess of pressure of the water on the upper surface of the disk, added to the weight of the disk in water and of the guide-wheels and wire in air.

There is therefore for every particular velocity of water a particular position of the disk from which it will not move until that velocity is changed. The particular rate in gallons per hour for each particular position of the disk had been determined, and a scale had been constructed on which a pencil, attached to the crosshead carrying the guide-wheels, shows at any instant the rate of flow in gallons per hour. In practice this scale is printed on a sheet of paper, which is mounted on a drum and caused to revolve once in 24 hours. By this means the rate of consumption in the district for every instant during the day and night is determined; and the waste of water is distinguished from the use of water by the comparatively steady nature of the line due to the latter. By placing a turning key on the plug of the stopcock outside any private premises during the night, and by applying the ear to the top of the key, any flow of water may be detected. If waste is thus found to be taking place the stopcock is closed.

The waste of a district is thus traced to a few premises, and on the following morning the diagram is found to have recorded the change of rate in the flow caused by the closing of each stopcock, and the degree in which the subsequent repairs should reduce the consumption.

The author concluded by stating that waste-water meters had been for some time in successful operation in Liverpool, where, until their application, the town was on intermittent supply at the rate of about twenty-five gallons per head per day for domestic purposes, which was found to rise above thirty-three gallons per head during an experimental constant supply.

Waste-water meters had, however, been applied in thirty-six districts, containing in the aggregate 89,502 persons, and the domestic consumption had been thereby reduced to 16·9 gallons per head per day, at a trifling cost and with but little annoyance to the people.

The system was being quickly extended to the whole district of supply.

On a new Method of Isometrical Drawing.* By George Fawcus.

On Coal Mining in Italy†. By P. le Neve Foster, jun.

On a New Form of Screw-Lowering Apparatus. By E. J. Harland.

The author, with the aid of models, gave a detailed description *vivâ voce* of a screw-lowering apparatus for ships which he had lately invented. He said that in some voyages, and especially during those across the Atlantic, the wave-line on the side of the ship was very often such as to leave the ordinary screw half exposed. Under these circumstances the engines had only half the work to do, and consequently were apt to run off at such speed as to injure the machinery. The consequence was that the engineer had to throttle or cut off a considerable portion of the steam, and the speed of the vessel was much reduced. To obviate that, a plan for lowering the screw was being introduced, which enabled the engineer in heavy weather to keep the vessel going much steadier, with practically very little reduced speed. A large amount of useful power was thus utilized, with the advantage of uniform motion.

Instead of the engineer being obliged at different parts of the day to slow the engines, he was independent of the weather, which became merely a matter for the

* Printed *in extenso* in 'The Engineer,' vol. xxxviii. p. 192.
† Printed *in extenso* in 'Engineering,' vol. xviii. p. 311.

consideration of the captain. In crossing a bar, or when in shallow water, the tips of the screw must not be lowered beneath the keel. The normal position of the screw was that the tip should be in a line with the keel; but when the vessel was in more water than she really required, the captain gave directions to the engineer to lower the screw, in performing which operation no change was necessary in the speed of the engines, and in that position the vessel crossed the ocean. On arriving near port the captain gave a counter order to raise the screw. In Liverpool the demand for admission into the graving-docks by vessels which had broken or injured their screws was often so great that it was found impossible to accommodate them all, and the consequence was that many vessels had to enter on another voyage with their screws in an injured condition. To meet this difficulty it was proposed to elevate the screw to such a position, as when the vessel was half discharged the screw could be repaired and then lowered to its normal position, without its being necessary to take the vessel into the dock.

Not more than two minutes are occupied in raising or lowering the screw, which was accomplished by means of a small steam-engine located on the deck.

In performing the operation there was, of course, a theoretical loss of power, although practically no loss could be discovered.

The Harland screw has been fitted to the White Star liner 'Britannic,' which has recently made one of the shortest runs on record to New York. The ship is 472 feet long, 45 feet beam, with a total carrying capacity of 5000 tons. She has compound engines 760 H.P. nominal and eight boilers, and developed great speed, making the passage in 7 days 19 hours and 35 minutes, which is within half an hour of the shortest time recorded.

The S.S. 'Camel,' a smaller steamer, has also been fitted with this lowering-screw, and in constant use during the last four years has given the utmost satisfaction.

On a Higher Education for Engineers.*
By JEREMIAH HEAD, *of Middlesbrough.*

The author first showed that the industrial prosperity of Great Britain, depending as it does so largely upon the economical utilization of its minerals, would in future increase or dwindle away according to the skill and intelligence brought to bear by British engineers.

He then investigated the meaning of the term "Engineer," calling attention to its ambiguity, and defining it as properly denoting "him who is able, as various necessities arise, to utilize, in the best and most economic manner, the materials of the earth for the benefit of its inhabitants."

In order to enable engineers really to come up to this high standard, he thought they should have a much wider and higher education than is now commonly met with among them. He argued at considerable length in favour of increased attention being paid to the studies of chemistry, physics, geology, physical geography, economics, mathematics, accounts, law, inductive and deductive reasoning, rhetoric, physiology, and professional morals. The nature of each of these branches of knowledge, and their bearing upon the engineering profession, were successively discussed.

He endorsed the present practice of sending students at the age of sixteen to work as ordinary mechanics in an engineering establishment of repute, and where there is a good system of progressive advancement through the several departments. But instead of remaining simply as improvers after the age of twenty-one, he advocated a three years' course at a good College of Science, where systematic attention could be paid to the above higher branches of professional education. He thought a longer time than has hitherto been customary should be devoted to the training of an engineer, and did not consider the responsibility of laying out large sums of money in constructive works should be entrusted to men of less than thirty years of age.

In conclusion, he called attention to the danger of specializing the energies too much, or before the elements in every department of knowledge have been

* Printed *in extenso* in 'Engineering,' vol. xviii. pp. 255, 280.

thoroughly mastered. Specialists are of two kinds, exciting respectively our aversion and our admiration. The first kind were like sellers of omnipotent medicines; they may possibly have an intimate acquaintance with the special articles they sell, but would be utterly helpless if called upon to deal with new conditions. The second kind he typified by Smeaton's Eddystone Lighthouse, which has withstood the fierce attacks of Atlantic storms for more than a century. Two previous ones failed because imperfectly constructed; but this one endures, because the lower one searches among the courses of masonry of which it is composed, the more solid one finds them, and the more extended in area, until they finally terminate in the granite blocks which are dovetailed into the solid rock.

Luke's Patent Safety Facing-point Lock for Securing Railway Facing-points. By R. Luke, *of the Great Western Railway.*

[Communicated by W. Smith, C.E., London.]

This invention consists in forming the extreme points of the switch-rails with a bevel projection thereon, which bevel projection may either be forged on or it may be fixed thereto by bolting, riveting, or otherwise. This projection is bevelled to an angle of 45 degrees, and the inner face of each switch-point is similarly provided, but the bevel on the one is right-handed and that on the other is left-handed. The points are connected together by a rod or rods, and they move in the arc of a circle in the usual way. The bevelled pieces on the points each project to an extent sufficiently wide to receive a correspondingly bevelled projection or the bevelled end of a longitudinally sliding-bar, which may be of sufficient length to receive at least two pairs of carriage-wheels; and these bars may work or slide longitudinally by the side of the inner faces of each permanent rail, or partly by the side of and partly under each rail, as will be further described. There are two such bars, each so formed or fitted with a bevelled end to correspond with and overlap the bevel projection on each point or movable tongue of the switch-rail.

These two longitudinal bars are connected together and moved simultaneously in opposite directions by the interposition of either bell-cranks and connecting-rods, or a vibrating lever mounted centrally upon a bearing between the rails for simultaneously moving the two bars. This vibrating lever may, in turn, be connnected with the points through bell-cranks and rods.

Knowing by practical experience that a single bar, when placed before facing-points, and upon which the flange of the wheel would have to run (or over which it would roll), would be subject to the kicking action of the driving-wheel of the engine, and such action would tend to withdraw the bevelled end of the bars from contact with the bevelled piece on the switch, the author accordingly provided a very simple means of overcoming that difficulty, which, though more *ideal* than *real*, presented itself as one of the objections which was likely to be raised by those over-refined and hypercritical critics who are far more ready at discovering objections to any plan proposed by others than in suggesting remedies. The author therefore provides two bars and connects them together; and it will be seen that, as they work in opposite directions, being connected together, whatever kicking is done to the *one bar* is counter-kicked and counteracted by the action on the *other bar*, so that the kicking, being self-neutralized, has no unlocking effect, and so leaves the locking of the points as effective as is provided and arranged for mechanically by the arrangement and disposition of the moving parts. But this kicking or creeping action only applies in the case where the rotating surface of the wheel (whether it be of the tread or the flange of the wheel) comes in contact with or rolls upon the longitudinal bar or longitudinally moving portion of the permanent rail; but it does not *at all* apply to those arrangements wherein the weight of the train is supported on the ordinary rail which has no longitudinal motion, and the rail in turn acts by pressure upon, and holds securely, a longitudinally sliding-piece or portion of the longitudinally sliding-bar that is beneath the foot or bottom of the rail, and which is only free to be moved or slid when there is no load or pressure on the permanent rail.

The movements of the points, or their vibration in the arc of a circle, and the longitudinal movements of the two sliding-bars, are effected simultaneously and correspondingly, and in proper relation to one another, either through the connexions that are provided or any other suitable arrangement, and the whole is worked or set in motion by means of *one* lever-handle or by the movement of *one* connecting-rod from the pointsman's box; and when, by the forward motion of one of the sliding-bars, the bevelled end thereof is pressed against the bevel on the point corresponding thereto, and forces the extreme point of the switch against the permanent rail, it holds it there until the whole of the train has passed over the points. As even the pointsman himself cannot move the lever or the bars or the points during the passage of an engine or train over or along the longitudinal bar, or over the rail under which or partly under and partly by the side of which the longitudinal sliding-bar is applied or fitted, by reason of the load or weight of the engine or carriage upon it, thus the pointsman or any other person would be prevented from moving this handle or the connecting-rod therefrom, or the sliding-bar itself, and so the position of the points cannot be changed; and they cannot be opened to the slightest extent whilst the train is approaching the points or until after the engine or train has entirely passed over them.

If the angles of the inclined surfaces of the projections from the longitudinally sliding-bar and from the points be other than 45°, the relation of the movements and the proportionate motions of the longitudinal bars and the vibrations of the points must be changed to correspond therewith, so that they pass the one incline surface over the face of the other when the bars, acting on the points, cause them to be alternately moved from or to the permanent rail.

The outside rod and mechanism of this point-locking apparatus are connected with the signals by means of rods in the usual way; and the protecting signals should first be moved over into the right position to protect the road before the points are moved; and the points should also be connected with a point-indicator, so as to show their true position by night as well as by day.

On the Great Western Railway, at the Portobello Junction, a combined broad-gauge and narrow-gauge line is fitted with facing-points according to this invention, and they have been in constant use for fourteen months; and, besides the sidings proper for the general traffic, the heaviest goods traffic into the goods yard has passed over the broad- as well as the narrow-gauge points at this Junction with entire satisfaction to the engineer and all concerned, and the pointsman speaks of the invention in the highest terms.

At Hammersmith Junction this apparatus has been applied to the narrow-gauge line where the Great Western and Metropolitan Railway systems join; and there, too, after about fourteen months' heavy work, although the apparatus was only roughly made up and put together, it has stood the severest tests to which it could be subjected, and has given every possible satisfaction.

The plan view of a narrow-gauge line, with a guard-rail on the inner side of each permanent rail, shows a longitudinally sliding-bar working between the inner face of each permanent rail and the guard-rail. It shows the movements of the two bars in opposite direction as being there produced by a lever-arm mounted on a sleeper between the rails, and the bevel end of each bar resting on a bed-piece or chair common (as a bearing) to it and the bevel projection on the end of the corresponding point, against the bevelled face of which the end of the sliding-bar is constantly in contact and ready to act or perform its function of moving the point over to, and firmly pressing it against, the permanent rail, either alone or conjointly, through or by the aid of the bell-crank or other connexions which may be introduced whenever thought to be desirable or advisable; but the use of bell-cranks for moving the points over in the arc of a circle is not really necessary, though many engineers may consider it a proper adjunct and precaution.

To suit the various forms of railway bars in use, and also the views of railway engineers, the inventor has proposed various modifications in the form and arrangement of the longitudinally sliding-bars, as far as possible to suit the various conditions of things.

*The River Shannon Drainage and Navigation**. By JAMES LYNAM, *C.E.*

The flood-waters of navigable rivers, such as the Shannon, may be far more easily, quickly, and economically regulated, and the crops on the adjacent lowlands preserved from inundations, by using *wholly movable weirs*, such as *the French "barrages mobiles,"* than by *wholly solid stone weir-mounds*, such as those built by the Board of Works, and now existing in the Shannon, or by the *immovable iron walls* with submerged sluices recently designed for the Shannon by an eminent civil engineer.

Works on a very large scale for the improvement of the river Shannon for both drainage and navigation were designed under the Act 5 & 6 William IV. chapter 6, and were carried on under the Act 2 & 3 Victoria, c. 61. The expenditure was about £586,000, of which one half was a free grant, and one half was levied on and paid up with interest by the riparian counties.

In 1850 the Commissioners reported the works complete and effective, but that was a double mistake. It is now ascertained by measurements and admitted that large portions of the works are still unexecuted, and that 24,000 acres of land are periodically damaged by the inundations. In August 1861 an inundation destroyed the whole of the crops, and nearly every year great damage is done. During the last thirteen years the subject has been much discussed. A Select Committee of the Lords and another of the Commons have sat on the subject, heard much evidence, and reported. Two engineering surveys of the river have been made and lodged in Parliament, together with designs and estimates for the improvement of the drainage. The cost of all these amounts to about £12,000, but no work has yet been done. The landowners have asked from the Board of Works permission to construct sluices in the solid stone weir-mounds, but the Board refused. At length, last session of Parliament, the present magnanimous Government got an Act passed appropriating £300,000 of public money for the improvement of the river, of which, as before, one half is to be a free grant, and one half is to be levied on and paid by the landowners with interest in thirty-five years. This half, viz. £150,000, is to be levied on an area of 18,000 acres, being at the rate of £8 6*s.* the English acre. Most of the owners of the flooded lands think this sum is more than the value of the benefit that would result to the lands from the drainage, and thus it remains very uncertain whether these landowners will give the formal legal assents to the project which the Act requires before works can be commenced. If works can be designed sufficient to improve the river to the extent necessary and desired for the sum of £200,000, one half of which, £100,000, levied on the lands would be but £5 11*s.* an acre, the landowners would freely give their assents, and a sum of £100,000 would be saved. That this can be done is what I here propose to show.

Under the recent Act of Parliament it is not proposed to improve the whole of the river Shannon, but only three out of the eight divisions or reaches, leaving one level or reach at Limerick below and four reaches above unimproved, and their lands still subject to injurious flooding.

The design for the improvement of those three levels at a cost of £300,000 to improve 19,000 acres comprises two principles, viz. increasing the water-way by excavation, and keeping up a depth of 6 feet to 7 feet of water on all the shoals and locksills in driest summer for steamboat navigation by *regulating-weirs*.

The existing regulating-weirs, as built across the Shannon by the Commissioners, are wholly solid stone *mounds* of a half-horseshoe form, with the leg lying very obliquely to the stream. There is no sluice or flood-gate in any of them. In wet weather and in floods they act as an artificial barrier to the passage of the surplus water. From Carrick on Shannon to Killaloe Bridge in mid flood is 35 feet 9 inches in the surface. Of this fall 20 feet is wasted in useless cataracts at six weir-mounds, and 15 feet 9 inches only in the intermediate reaches to propel the stream.

The regulating-weir proposed and designed recently by the Government in lieu of the existing weir-mounds is an immovable iron wall with submerged opes for sluices. Each ope is 6 feet broad and 4 feet deep, and surrounded on the top, sides, and bottom by the edges of the iron plates of the wall. The weir is 8 feet

* Printed *in extenso* in 'The Engineer,' vol. xxxviii. p. 273.

deep, and therefore the upperside of each sluice when fully open is 4 feet submerged under water. When all the sluices are open to the fullest possible extent, the aggregate water-way is but one third of the sectional area of the river. Two thirds of the water-way is permanently shut. To meet this great contraction the Government engineer has designed very large excavations; and he provides for a head or difference of level between the water at the upper and lower sides of the river of about 2 feet.

At Killaloe the existing fall in the surface of the flood-water is $6\frac{1}{2}$ feet in a distance of 4400 feet, being at the rate of $7\frac{1}{2}$ feet per mile. Out of this fall of $6\frac{1}{2}$ feet, the head which the engineer provides for propelling the flood-water through his sluice-opes is 2 feet 2 inches. Thus a third of the whole available fall is appropriated to the weir, and two thirds merely to the river.

By using a regulating-weir wholly movable, such as the "barrages mobiles," of which forty have been in action in the rivers Seine and Yonne for several years, no head is required, none of the natural fall of the river is wasted, the whole is disposed along the surface of the river to actuate the current. Of course far less excavation is then required to carry off the flood-waters.

At Killaloe on the Shannon the Government engineer has been obliged to estimate for the following excavation:—

177,785 cube yards of rock at 2*s*. . .	£17,778
59,515 cube yards of clay at 9*d*. . .	2,231
Amount	£20,009

With present prices that would cost £25,000.

The existing channel, with the surface of the river above at a level that will injure no crop, affords a fall at the rate of $6\frac{1}{2}$ feet per mile, and a cross sectional water-way 430 feet broad and 6 feet deep. This will carry 1,230,000 cube feet of water per minute. The greatest quantity of flood-water he proposes to provide for the discharge of there is 1,200,000 cube feet per minute. There, with a wholly movable weir, the existing channel is sufficient, and the proposed excavation is not necessary. Therefore works for the improvement of the Shannon at Killaloe, sufficient to improve the drainage of the division of the river above it without injuring the division below it, may be designed at a cost certainly £20,000 less than the estimate recently made by the Government engineer, by using a wholly movable regulating-weir.

Proportionate savings may be effected on the same principle in the other divisions of the river.

It has been stated that a wholly movable weir at Killaloe would injure the navigation there by causing a violent current. An inspection of the map of the river there will convince all unprejudiced minds that no such evil could result. The Canal protection embankment shown by the yellow shade, which the Commissioners partly cut away, must be restored at a cost of £1000, both for the iron wall weir and for a movable weir, and then the navigation channel will not be at all affected by any current in the river.

I do not state that the French "barrages mobiles," with their mechanical details, are the most suitable pattern of regulating-weir for the Shannon. All I advocate is, a regulating-weir either wholly movable or so far movable that when fully open it will occupy a head of water in high floods of no more than 3 inches. Such a weir may easily be designed and constructed in lieu of the existing *stone weir-mounds* in the Shannon without any injury to the navigation, and by their use so much more fall will be effective in propelling the stream along the different reaches of the river that very little excavation to increase the water-way will be required; and the drainage and the navigation of the Shannon may be improved to the fullest extent necessary or desired at a cost of £100,000 less than the estimate on which the recent Act of Parliament is founded.

Determination of the Form of the Dome of Uniform Stress.
By C. W. Merrifield, *F.R.S.*

The author had observed that there was a considerable simplification in the

analysis of this problem, when it was considered as subjected to the two conditions which were necessary to the most economical use of a homogeneous material, namely,—

(1) That the thrust along a meridian shall equal the thrust along the parallel per unit of area at every point.
(2) That the normal thickness shall vary in such a manner that the area under compression shall be proportional to the thrust.

The paper contains the investigation of the differential equation of the profile of the dome subject to these conditions, and the discussion of that equation, as well as of the law of variation of thickness under the same conditions. The theorems are also extended to the case of stratified stone, in which the thrusts in condition (1) are proportional instead of equal.

The investigation is printed *in extenso* in the 'Proceedings of the London Mathematical Society' for 1874, vol. v. pp. 113–119.

On an Improved Tuyere for Smiths' Forges. By W. MORGAN.

This is a simple but important improvement in smiths' forges, by which the forge is much more fully under the control of the workman, and by which the life of the tuyere is greatly prolonged, the work of heating the metal more uniformly and uninterruptedly carried on, and a great economy of fuel effected. A cast-iron trunk or box is made which is placed horizontally from the back and the front of the forge. The front end is closed by means of a slide or door; the back end has a hollow tower, which rises above to a suitable height, and upon which is fitted a cast-iron tuyere-block with, by preference, two long slot-holes for the blast. Within the trunk is a long lever working in an axle or spindle, which at its longer end has two punches, which rise vertically, and are from time to time projected through the slots to displace the slag, and keep the tuyere-openings clear. This the workman does by moving a lever upon the outer end of the spindle or fulcrum of the levers. The iron trunk or box becomes heated by the surrounding fuel, and utilizes the heat which would otherwise be wasted, and effects a considerable economy of fuel by heating the air of the blast, and the inventor employs air in a peculiar manner for keeping the tuyere-block cold.

On the means adopted for the Improvement of the Outer Navigable Channel of Dundalk Harbour. By JOHN NEVILLE, *C.E., M.R.I.A.*

The harbour of Dundalk is entered by a channel 4 miles long from and in the bay, beginning at the bar and terminating at Soldiers Point. This channel, called the "Outer Channel," discharges the waters of the Castletown River at low water. In 1867 it had shifted so much that it became necessary to alter its course and fix it. A plan for this purpose was selected by the Harbour Commissioners, and approved of by the Board of Trade. This consisted of directing the ebb and flow currents into a more direct course, and fixing this course by means of jetties and side walls constructed of loose rubble boulder-stones, varying in weight from a few pounds to a few cwts., dropped in from punts, and raised about 2 feet over low water neap-tides. The stones were not quarried, but picked from off the lands on the mountain side near the shore, carted to the shipping-places by the farmers, and sent out in punts. About 60,000 tons have been deposited up to the present time; about 2 miles of jetties and walls have been constructed, and about £8000 expended out of an estimate of £40,000. As the income of the Commissioners is limited, the works are carried on from time to time as the funds are available. It was at first thought by many that at a distance of a mile or two from the shore, the loose stones in these jetties and walls would be washed away. This has not been so. Not a single stone has been removed; but when subsidence takes place new materials are supplied, and the walls raised up from time to time as before. The jetties, or grains, were used to force back the channel gradually, in some cases to an extent of about 700 feet without any interruption of the navigation. This communication

was laid before the Section for the purpose of showing that guide-walls, if not too high, can be constructed with small stones in a cheap and effective way to direct the currents, and maintain a channel at a considerable distance from the shore in bays and estuaries.

A new Construction for finding the Vertical Shearing-stress and the point of greatest Bending-moment in a Beam loaded in any way. By JOHN NEVILLE, *C.E., M.R.I.A.*

The vertical shearing-stress of a beam at any point is known to be equal to the weight on the next pier less the weight lying between this pier and the point. It is generally represented, graphically, by ordinates to the beam of one side only. Now as the sum of these stresses must be zero, those on one side being positive and those on the other negative, the proper graphical representation is to show them according to their signs above and below the beam, positive and negative as they exist. This leads to a simple geometrical construction for finding the shearing-stress on a beam loaded in any way with a number of weights. Find the line of shearing-stress for the beam itself; then using *this line* plot on it the line of shearing-stress for the first weight, distributed or single, but making the ordinates vertical to the beam itself. Plot from this second shearing-line a third shearing-line for the third weight, and so on. The shearing-line last found gives the shearing-stress of the beam arising from all the weights, including that of the beam. The construction gives the lines of shearing-stress for each point of the beam at each step also.

Where the shearing-stress is a maximum, the bending-moment is zero; and where the shearing-stress is zero, the bending-moment is a maximum. Consequently where the line of shearing-stress, as here constructed, cuts the beam, the point of intersection is that of the greatest bending-moment.

The areas formed between the line of beam and the lines of shearing-stress, above and below, are always equal.

Improved Patent Saddle-rail and Railway Permanent-way Construction. *By* W. SEATON.

The author first explained his original saddle-rail, which had been in satisfactory use upon various railways throughout the country, including the Great Western Railway, where for fifteen years uninterruptedly it had continued in use. On the Highland Railway it had been laid and maintained with great economy.

The improvements now made consisted of rolling the saddle-rail with flanches and introducing transverse sleepers under the longitudinals, and bolting the rails by the flanches vertically through the longitudinal bearers and the transverse sleepers, thus combining the whole together in a firm framework-like structure without any understrain upon or injury to the bolts or fastenings—the introduction of transverse sleepers under the longitudinals giving a much wider base to the road and a much stronger vertical and lateral resistance to rolling loads worked at high speeds, with a great reduction and cost of materials and economy of first cost for construction and maintenance of the permanent way.

On the Prevention of Railway Accidents and Automatically Recording the Movements of the Points and Signals and other Apparatus of Railways. *By* W. SMITH, *C.E.*

The author prepared this paper as supplementing that portion of the President's address read before the Section at its opening in which he gave a brief sketch of the improvements that had recently been effected in the working of railway-traffic, and wherein he shortly described the "block system," the signalling arrangements, and the "interlocking of the points and signals by mechanical means," so that a mechanical check was set upon the signalman, who could not pull over certain of the point- and signal-levers until certain others were first put right, and whereby every thing was moved and worked according to a prearranged system.

For the invention of this interlocking of the points and signals of railways, and the arrangement of mechanism designed to prevent the confliction of the signals with one another and of the signals with the points, we are indebted to Mr. John Saxby, a very ingenious inventor, formerly in the employ of the London, Brighton, and South Coast Railway Company, and now the proprietor jointly with his partner, Mr. J. S. Farmer, of one of the most extensive and well-arranged manufacturing establishments in the country, employing between 3000 and 4000 hands and a large capital mainly, if not entirely, created during the last twelve or thirteen years.

The great originality and ingenuity of the Saxby and Farmer interlocking apparatus, and its capabilities for adaptation to the most complicated and labyrinthic arrangements of railway-lines and traffic-working at the junctions, stations, and termini of railways, has been the means of so systematizing the working that perfect safety may be relied on, so long as the signals can be seen and the engine-driver promptly and thoroughly respects them; but, unfortunately, these conditions are not at all times observed, and serious accidents frequently occur, as will be found on reference to the Board of Trade reports by Captain Tyler and other Government inspectors from time to time.

Whenever accidents do occur from the disregard of the signals by the engine-driver, or from his inability to see them, a conflict in the evidence given at a coroner's inquest, or at a Government or other inquiry, is invariably the result; and whilst the signalman states that the signals were "against the driver," or at "danger," the driver and his mate (and sometimes others in the train) assert the direct contrary.

In many other ways in connexion with the direction of the traffic and traffic-working, that which has been done or that which should have been done, but has not been done (but whichever it is or may have been), has produced directly, or has been more or less immediately the cause of, serious accidents, and loss of life and property has remained untraced or imperfectly accounted for or explained. Such occurrences, when they take place, are unsatisfactory, and frequently involve serious injustice to some guiltless or innocent persons.

The author has, during his experience and practice as a scientific expert, whilst engaged investigating the causes of railway accidents, had his attention called to the great importance of providing some thoroughly reliable apparatus and arrangement by the use of, and reference to, which all doubts would be set at rest as to the actual condition of the "home" and "distant" signals, and the points and switches, the level-crossing gates, and other movable portions of the machinery of railways and of the trains thereon, at any given period of time, at and near to every signal-box, junction, or station.

To effect these objects, and to do so automatically, and preserve a perfectly intelligible and reliable record of every telegraphic direction or signalled instruction sent and received for the movement or working of the train-signals, "day" and "night," "home" and "distant," semaphore or other, and for the movements of the "points" and other portions of the rails or permanent way connected with the regulation of the movements or translation of the traffic over the main or branch roads and other portions of the system, the author was requested to design and provide some reliable and inexpensive apparatus. Accordingly he undertook the task some two years ago, and after an extensive series of experiments and trials, under every variety of circumstances connected with the working of railway traffic, he succeeded in arranging a most complete and comprehensive apparatus which automatically records:—

1st. The directions given and received for regulating the movements of trains;

2nd. The movement of every signal of every kind or description;

3rd. The movement of the "points" and other portions of the road and way affecting or regulating the movements of trains or engines;

4th. The passing of trains in each direction; and

5th. The time in relation to such movements &c. All upon the same roll or strip of paper and in a succinct form.

These results are obtained by connecting to the reciprocating parts of the point- and signal-working apparatus, or to the interlocking gear, a peculiar arrangement

of electric contact-making and breaking apparatus, acting through a simple electro-magnetic contrivance which in turn operates upon and deflects a pen, style, or marker, which records upon the strip of accurately divided paper the whole of the movements in question. In like manner, the directions sent and received for regulating the traffic are recorded, as also is the passing of trains, which are distinguished the one from the other; and the whole of these movements are timed, and the time is recorded uniformly on one edge of each of the strips of paper.

Between the time-records on the one edge of the roll or strip and the passage of trains recorded, say, on the opposite edge, the directions sent and received and the movements of the various signal- and point-levers, or the movements of the parts of the interlocking gear, are recorded between the records on the two edges of the strip, and in a clear and intelligible manner; and on reference to these rolls all questions connected with the traffic-working can be solved with perfect certainty; and upon the rolls or strips of record-rolls being removed and sent to the manager's office, he can, at a glance, by comparing the various records, see the work done upon the various parts of the line during a given time; and they can be referred to at any time, and could be produced and could be received as reliable evidence in any legal or other tribunal.

The apparatus costs only a small sum, and the annual cost of maintaining and working it is very small.

On Improvements in the Mariner's Compass. *By* Sir W. Thomson, *LL.D., F.R.S.*

On Power-Couplings for Rolling-Mills and other Machinery. *By* F. H. Varley *and* Edw. Furness.

In arresting a heavy body in motion it is necessary to exert a force equal to the dynamic effect of the weight of the body, multiplied by the square of its velocity. Should this be effected instantaneously, a great concussion is the result—such being the effect experienced when a piece of machinery in rapid rotation is suddenly arrested by clogging, causing the teeth of the wheels to be stripped off or the shafts broken or distorted, which frequently occurs with iron rolling-mills, sugar-cane crushing-mills, and not unfrequently causing the breaking of the screw-shafts of steam-vessels and all classes of machinery subject to rapidly varying strains. To reduce these enormous strains to within the working strength of the material of which the machinery is constructed, it is necessary to spread the force of the concussion over a portion of a revolution or revolutions, or period of times, and so destroy its intensity. Contrivances for effecting this purpose have hitherto taken the shape of friction-breaks or clutches. They, however, are open to the objection that they consume a large amount of useful power by generating heat and destroying the surface by abrasion. The authors describe a means of obtaining a better result by an hydraulic pressure, rendered elastic by placing in the fluid a number of elastic bodies, such pressure acting against the face of a ram working in a cylinder. To convert the longitudinal motion of the ram into the rotatory motion of the shaft they employ the following arrangement:—The wheel which communicates the power to the machinery is bored to fit freely on a shaft, and has a boss with its face on the inner side shaped of a spiral incline of screw form, and which is made to bear against an annular plunger, the outer end of which is shaped to the contrary screw form. The hole in the plunger is bored to the same size as the wheel, and works in a cylinder fitted concentrically on the shaft which passes through the hole of the ram and wheel, the ram being made watertight by suitable packing or leather. The outer end or mouth of the cylinder has slots or recesses cut into it longitudinally in which lugs or projections on the ram work, so that the ram can slide in and out the cylinder, but cannot turn unless the cylinder turns with it, proper inlets for charging the cylinder with fluid and elastic balls being provided. If the shaft be revolving, and the wheel driving the machinery is stopped, the ram is immediately pressed into the cylinder and compresses the

elastic material placed in the fluid by the spirally inclined faces rising upon one another; the wheel at the same time is prevented from moving laterally along the shaft by a fixed collar. On the outer side of the wheel this motion of the ram allows the shaft to continue its rotation, while the wheel is held by a sudden shock or stoppage; so that the machinery in such emergencies is gradually pulled up without being smashed to pieces. In crushing-mills, through too heavy a feed, the rolls only require to be allowed to slacken in speed to admit of the cane yielding under the pressure. When the obstacle to rapid rotation has passed the rolls, the pressure stored up in the cylinder reacts on the ram, and by the spirally inclined end acting on the counter-form boss of the wheel, quickly brings the rolls to the speed of the driving-shaft, and thus utilizes the force of the strain.

On Recent Improvements in Breech-loading Firearms. By Andrew Wyley.

In continuation of a paper read at Brighton in 1872, giving an outline of the history of breech-loading firearms, some account was given of improvements since that date, including four different systems by the author, examples of which were exhibited and described. The very serious defects of the "Martini-Henry" rifle, as adopted by the British Government, were pointed out and illustrated by a "sectional" model of that arm.

On the Breech-loading Firearms exhibited at Vienna in 1873. *By* Andrew Wyley.

A short account was given of these, attention being specially directed to the very excellent collection of modern breech-loaders contributed by the associated gunmakers of Liége, in which were represented some fifty systems, many of them quite unknown in this country. It was remarked that, although at present we have no such collection, the want is likely to be shortly supplied in the Museum of Arms about to be established in Birmingham by the "Wardens of the Proof House," who have secured, as a foundation for the same, an admirable collection made in Italy by Cavaliere Callandra, illustrating the manufacture of firearms from the earliest period up to the introduction of the percussion lock, and containing many examples of the highest artistic excellence*.

Some account was also given of the great factory of the Austrian Government at Steyer and Letten, on the Ems, which can turn out 150,000 "Wernal" rifles and 100 "mitrailleuses" yearly, of Herr Dreyse's establishment at Sommerda, in Saxony (Prussian), famous for the production of the Prussian "Zündnadel," and of a curious cooperative factory at Ferlaeh, in Carinthia, where low-priced sporting guns and pistols are made on a large scale for the markets of Eastern Europe.

* The Museum was opened on the 24th September, 1874.

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[*An asterisk* (*) *signifies that no abstract of the communication is given.*]

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CONTENTS:—Proceedings of the Meeting;—John Taylor, on Mineral Veins;—Dr. Lindley, on the Philosophy of Botany;—Dr. Henry, on the Physiology of the Nervous System;—P. Barlow, on the Strength of Materials;—S. H. Christie, on the Magnetism of the Earth;—Rev. J. Challis, on the Analytical Theory of Hydrostatics and Hydrodynamics;—G. Rennie, on Hydraulics as a Branch of Engineering, Part I.;—Rev. G. Peacock, on certain Branches of Analysis.

Together with papers on Mathematics and Physics, Philosophical Instruments and Mechanical Arts, Natural History, Anatomy, Physiology, and History of Science.

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Rev. J. Challis, on Capillary Attraction;—Prof. Lloyd, on Physical Optics;—G. Rennie, on Hydraulics, Part II.

Together with the Transactions of the Sections, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FIFTH MEETING, at Dublin, 1835, *Published at* 13*s.* 6*d.*

CONTENTS:—Rev. W. Whewell, on the Recent Progress and Present Condition of the Mathematical Theories of Electricity, Magnetism, and Heat; — A. Quetelet, Aperçu de l'Etat actuel des Sciences Mathématiques chez les Belges;—Capt. E. Sabine, on the Phenomena of Terrestrial Magnetism.

Together with the Transactions of the Sections, Prof. Sir W. Hamilton's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE SIXTH MEETING, at Bristol, 1836, *Published at* 12*s.*

CONTENTS:—Prof. Daubeny, on the Present State of our Knowledge with respect to Mineral and Thermal Waters;—Major E. Sabine, on the Direction and Intensity of the Terrestrial Magnetic Force in Scotland;—J. Richardson, on North American Zoology;—Rev. J. Challis, on the Mathematical Theory of Fluids;—J. T. Mackay, a Comparative View of the more remarkable Plants which characterize the neighbourhood of Dublin and Edinburgh, and the South-west of Scotland, &c.;—J. T. Mackay, Comparative Geographical Notices of the more remarkable Plants which characterize Scotland and Ireland;—Report of the London Sub-Committee of the Medical Section on the Motions and Sounds of the Heart;—Second Report of the Dublin Sub-Committee on the Motions and Sounds of the Heart;—Report of the Dublin Committee on the Pathology of the Brain and Nervous System;—J. W. Lubbock, Account of the Recent Discussions of Observations of the Tides;—Rev. B. Powell, on determining the Refractive Indices for the Standard Rays of the Solar Spectrum in various media;—Dr. Hodgkin, on the Communication between the Arteries and Absorbents;—Prof. Phillips, Report of Experiments on Subterranean Temperature;—Prof. Hamilton, on the Validity of a Method recently proposed by G. B. Jerrard, for Transforming and Resolving Equations of Elevated Degrees.

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PROCEEDINGS OF THE EIGHTH MEETING, at Newcastle, 1838, *Published at* 15*s.*

CONTENTS:—Rev. W. Whewell, Account of a Level Line, measured from the Bristol Chan-

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Together with the Transactions of the Sections, Mr. Murchison's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE NINTH MEETING, at Birmingham, 1839, *Published at* 13*s.* 6*d.* (Out of Print.)

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PROCEEDINGS OF THE ELEVENTH MEETING, at Plymouth, 1841, *Published at* 13*s.* 6*d.*

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Together with the Transactions of the Sections, Earl of Rosse's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FOURTEENTH MEETING, at York, 1844, *Published at* £1.

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Together with the Transactions of the Sections, Sir R. I. Murchison's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE SEVENTEENTH MEETING, at Oxford, 1847, *Published at* 18*s.*

CONTENTS:—Prof. Langberg, on the Specific Gravity of Sulphuric Acid at different degrees of dilution, and on the relation which exists between the Development of Heat and the coincident contraction of Volume in Sulphuric Acid when mixed with Water;—R. Hunt, Researches on the Influence of the Solar Rays on the Growth of Plants;—R. Mallet, on the Facts of Earthquake Phenomena;—Prof. Nilsson, on the Primitive Inhabitants of Scandinavia;—W. Hopkins, Report on the Geological Theories of Elevation and Earthquakes;—Dr. W. B. Carpenter, Report on the Microscopic Structure of Shells;—Rev. W. Whewell and Sir James C. Ross, Report upon the Recommendation of an Expedition for the purpose of completing our knowledge of the Tides;—Dr. Schunck, on Colouring Matters;—Seventh Report of the Committee on the Vitality of Seeds;—J. Glynn, on the Turbine or Horizontal Water-Wheel of France and Germany;—Dr. R. G. Latham, on the present state and recent progress of Ethnographical Philology;—Dr. J. C. Prichard, on the various methods of Research which contribute to the Advancement of Ethnology, and of the relations of that Science to other branches of Knowledge;—Dr. C. C. J. Bunsen, on the results of the recent Egyptian researches in reference to Asiatic and African Ethnology, and the Classification of Languages;—Dr. C. Meyer, on the Importance of the Study of the Celtic Language as exhibited by the Modern Celtic Dialects still extant;—Dr. Max Müller, on the Relation of the Bengali to the Arian and Aboriginal Languages of India;—W. R. Birt, Fourth Report on Atmospheric Waves;—Prof. W. H. Dove, Temperature Tables, with Introductory Remarks by Lieut.-Col. E. Sabine;—A. Erman and H. Petersen, Third Report on the Calculation of the Gaussian Constants for 1829.

Together with the Transactions of the Sections, Sir Robert Harry Inglis's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE EIGHTEENTH MEETING, at Swansea, 1848, *Published at* 9*s.*

CONTENTS:—Rev. Prof. Powell, A Catalogue of Observations of Luminous Meteors;—J. Glynn on Water-pressure Engines;—R. A. Smith, on the Air and Water of Towns;—Eighth Report of Committee on the Growth and Vitality of Seeds;—W. R. Birt, Fifth Report on Atmospheric Waves;—E. Schunck, on Colouring Matters;—J. P. Budd, on the advantageous use made of the gaseous escape from the Blast Furnaces at the Ystalyfera Iron Works;—R. Hunt, Report of progress in the investigation of the Action of Carbonic Acid on the Growth of Plants allied to those of the Coal Formations;—Prof. H. W. Dove, Supplement to the Temperature Tables printed in the Report of the British Association for 1847;—Remarks by Prof. Dove on his recently constructed Maps of the Monthly Isothermal Lines of the Globe, and on some of the principal Conclusions in regard to Climatology deducible from them; with an introductory Notice by Lt.-Col. E. Sabine;—Dr. Daubeny, on the progress of the investigation on the Influence of Carbonic Acid on the Growth of Ferns;—J. Phillips, Notice of further progress in Anemometrical Researches;—Mr. Mallet's Letter to the Assistant-General Secretary;—A. Erman, Second Report on the Gaussian Constants;—Report of a Committee relative to the expediency of recommending the continuance of the Toronto Magnetical and Meteorological Observatory until December 1850.

Together with the Transactions of the Sections, the Marquis of Northampton's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE NINETEENTH MEETING, at Birmingham, 1849, *Published at* 10*s.*

CONTENTS:—Rev. Prof. Powell, A Catalogue of Observations of Luminous Meteors;—Earl of Rosse, Notice of Nebulæ lately observed in the Six-feet Reflector;—Prof. Daubeny, on the Influence of Carbonic Acid Gas on the health of Plants, especially of those allied to the Fossil Remains found in the Coal Formation;—Dr. Andrews, Report on the Heat of Combination;—Report of the Committee on the Registration of the Periodic Phenomena of Plants and

Animals;—Ninth Report of Committee on Experiments on the Growth and Vitality of Seeds; —F. Ronalds, Report concerning the Observatory of the British Association at Kew, from Aug. 9, 1848 to Sept. 12, 1849;—R. Mallet, Report on the Experimental Inquiry on Railway Bar Corrosion;—W. R. Birt, Report on the Discussion of the Electrical Observations at Kew.

Together with the Transactions of the Sections, the Rev. T. R. Robinson's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTIETH MEETING, at Edinburgh, 1850, *Published at* 15*s*. (Out of Print.)

CONTENTS:—R. Mallet, First Report on the Facts of Earthquake Phenomena;—Rev. Prof. Powell, on Observations of Luminous Meteors;—Dr. T. Williams, on the Structure and History of the British Annelida;—T. C. Hunt, Results of Meteorological Observations taken at St. Michael's from the 1st of January, 1840 to the 31st of December, 1849;—R. Hunt, on the present State of our Knowledge of the Chemical Action of the Solar Radiations;—Tenth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Major-Gen. Briggs, Report on the Aboriginal Tribes of India;—F. Ronalds, Report concerning the Observatory of the British Association at Kew;—E. Forbes, Report on the Investigation of British Marine Zoology by means of the Dredge;—R. MacAndrew, Notes on the Distribution and Range in depth of Mollusca and other Marine Animals, observed on the coasts of Spain, Portugal, Barbary, Malta, and Southern Italy in 1849;—Prof. Allman, on the Present State of our Knowledge of the Freshwater Polyzoa;—Registration of the Periodical Phenomena of Plants and Animals;—Suggestions to Astronomers for the Observation of the Total Eclipse of the Sun on July 28, 1851.

Together with the Transactions of the Sections, Sir David Brewster's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-FIRST MEETING, at Ipswich, 1851, *Published at* 16*s*. 6*d*.

CONTENTS:—Rev. Prof. Powell, on Observations of Luminous Meteors;—Eleventh Report of Committee on Experiments on the Growth and Vitality of Seeds;—Dr. J. Drew, on the Climate of Southampton;—Dr. R. A. Smith, on the Air and Water of Towns: Action of Porous Strata, Water and Organic Matter;—Report of the Committee appointed to consider the probable Effects in an Economical and Physical Point of View of the Destruction of Tropical Forests;—A. Henfrey, on the Reproduction and supposed Existence of Sexual Organs in the Higher Cryptogamous Plants;—Dr. Daubeny, on the Nomenclature of Organic Compounds;—Rev. Dr. Donaldson, on two unsolved Problems in Indo-German Philology;—Dr. T. Williams, Report on the British Annelida;—R. Mallet, Second Report on the Facts of Earthquake Phenomena;—Letter from Prof. Henry to Col. Sabine, on the System of Meteorological Observations proposed to be established in the United States;—Col. Sabine, Report on the Kew Magnetographs;—J. Welsh, Report on the Performance of his three Magnetographs during the Experimental Trial at the Kew Observatory;—F. Ronalds, Report concerning the Observatory of the British Association at Kew, from September 12, 1850 to July 31, 1851;—Ordnance Survey of Scotland.

Together with the Transactions of the Sections, Prof. Airy's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-SECOND MEETING, at Belfast, 1852, *Published at* 15*s*.

CONTENTS:—R. Mallet, Third Report on the Facts of Earthquake Phenomena;—Twelfth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1851–52;—Dr. Gladstone, on the Influence of the Solar Radiations on the Vital Powers of Plants;—A Manual of Ethnological Inquiry;—Col. Sykes, Mean Temperature of the Day, and Monthly Fall of Rain at 127 Stations under the Bengal Presidency;—Prof. J. D. Forbes, on Experiments on the Laws of the Conduction of Heat;—R. Hunt, on the Chemical Action of the Solar Radiations;—Dr. Hodges, on the Composition and Economy of the Flax Plant;—W. Thompson, on the Freshwater Fishes of Ulster;—W. Thompson, Supplementary Report on the Fauna of Ireland;—W. Wills, on the Meteorology of Birmingham;—J. Thomson, on the Vortex-Water-Wheel;—J. B. Lawes and Dr. Gilbert, on the Composition of Foods in relation to Respiration and the Feeding of Animals.

Together with the Transactions of the Sections, Colonel Sabine's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-THIRD MEETING, at Hull, 1853, *Published at* 10*s*. 6*d*.

CONTENTS:—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1852–53;—James Oldham, on the Physical Features of the Humber;—James Oldham, on the Rise, Progress, and Present Position of Steam Navigation in Hull;—William Fairbairn, Experimental Researches to determine the Strength of Locomotive Boilers, and the causes which lead to Explosion;—J. J. Sylvester, Provisional Report on the Theory of Determinants;—Professor Hodges, M.D., Report on the Gases evolved in Steeping Flax, and on the Composition and Economy of the Flax Plant;—Thirteenth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Robert Hunt, on the Chemical Action of the Solar Radiations;—John P. Bell, M.D., Observations on the Character and Measurements of Degradation of the Yorkshire Coast; First Report of Committee on the Physical Character of the Moon's Surface, as compared with that of the Earth;—R. Mallet, Provisional Report on Earthquake Wave-Transits; and on Seismometrical Instruments;—William Fairbairn, on the Mechanical Properties of Metals as derived from repeated Meltings, exhibiting the maximum point of strength and the causes of deterioration;—Robert Mallet, Third Report on the Facts of Earthquake Phenomena (continued).

Together with the Transactions of the Sections, Mr. Hopkins's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-FOURTH MEETING, at Liverpool, 1854, *Published at* 18*s*.

CONTENTS:—R. Mallet, Third Report on the Facts of Earthquake Phenomena (continued);—Major-General Chesney, on the Construction and General Use of Efficient Life-Boats;—Rev. Prof. Powell, Third Report on the present State of our Knowledge of Radiant Heat;—Colonel Sabine, on some of the results obtained at the British Colonial Magnetic Observatories;—Colonel Portlock, Report of the Committee on Earthquakes, with their proceedings respecting Seismometers;—Dr. Gladstone, on the influence of the Solar Radiations on the Vital Powers of Plants, Part 2;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1853–54;—Second Report of the Committee on the Physical Character of the Moon's Surface;—W. G. Armstrong, on the Application of Water-Pressure Machinery;—J. B. Lawes and Dr. Gilbert, on the Equivalency of Starch and Sugar in Food;—Archibald Smith, on the Deviations of the Compass in Wooden and Iron Ships;—Fourteenth Report of Committee on Experiments on the Growth and Vitality of Seeds.

Together with the Transactions of the Sections, the Earl of Harrowby's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-FIFTH MEETING, at Glasgow, 1855, *Published at* 15*s*.

CONTENTS:—T. Dobson, Report on the Relation between Explosions in Coal-Mines and Revolving Storms;—Dr. Gladstone, on the Influence of the Solar Radiations on the Vital Powers of Plants growing under different Atmospheric Conditions, Part 3;—C. Spence Bate, on the British Edriophthalma;—J. F. Bateman, on the present state of our knowledge on the Supply of Water to Towns;—Fifteenth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1854–55;—Report of Committee appointed to inquire into the best means of ascertaining those properties of Metals and effects of various modes of treating them which are of importance to the durability and efficiency of Artillery;—Rev. Prof. Henslow, Report on Typical Objects in Natural History;—A. Follett Osler, Account of the Self-Registering Anemometer and Rain-Gauge at the Liverpool Observatory;—Provisional Reports.

Together with the Transactions of the Sections, the Duke of Argyll's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-SIXTH MEETING, at Cheltenham, 1856, *Published at* 18*s*.

CONTENTS:—Report from the Committee appointed to investigate and report upon the effects produced upon the Channels of the Mersey by the alterations which within the last fifty years have been made in its Banks;—J. Thomson, Interim Report on progress in Researches on the Measurement of Water by Weir Boards;—Dredging Report, Frith of Clyde, 1856;—Rev. B. Powell, Report on Observations of Luminous Meteors, 1855–1856;—Prof. Bunsen and Dr. H. E. Roscoe, Photochemical Researches;—Rev. James Booth, on the Trigonometry of the Parabola, and the Geometrical Origin of Logarithms;—R. MacAndrew, Report

on the Marine Testaceous Mollusca of the North-east Atlantic and Neighbouring Seas, and the physical conditions affecting their development;—P. P. Carpenter, Report on the present state of our knowledge with regard to the Mollusca of the West Coast of North America;—T. C. Eyton, Abstract of First Report on the Oyster Beds and Oysters of the British Shores;—Prof. Phillips, Report on Cleavage and Foliation in Rocks, and on the Theoretical Explanations of these Phenomena: Part I.;—Dr. T. Wright on the Stratigraphical Distribution of the Oolitic Echinodermata;—W. Fairbairn, on the Tensile Strength of Wrought Iron at various Temperatures;—C. Atherton, on Mercantile Steam Transport Economy;—J. S. Bowerbank, on the Vital Powers of the Spongiadæ;—Report of a Committee upon the Experiments conducted at Stormontfield, near Perth, for the artificial propagation of Salmon;—Provisional Report on the Measurement of Ships for Tonnage;—On Typical Forms of Minerals, Plants and Animals for Museums;—J. Thomson, Interim Report on Progress in Researches on the Measurement of Water by Weir Boards;—R. Mallet, on Observations with the Seismometer;—A. Cayley, on the Progress of Theoretical Dynamics;—Report of a Committee appointed to consider the formation of a Catalogue of Philosophical Memoirs.

Together with the Transactions of the Sections, Dr. Daubeny's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-SEVENTH MEETING, at Dublin, 1857, *Published at 15s.*

Contents:—A. Cayley, Report on the Recent Progress of Theoretical Dynamics;—Sixteenth and final Report of Committee on Experiments on the Growth and Vitality of Seeds;—James Oldham, C.E., continuation of Report on Steam Navigation at Hull;—Report of a Committee on the Defects of the present methods of Measuring and Registering the Tonnage of Shipping, as also of Marine Engine-Power, and to frame more perfect rules, in order that a correct and uniform principle may be adopted to estimate the Actual Carrying Capabilities and Working-Power of Steam Ships;—Robert Were Fox, Report on the Temperature of some Deep Mines in Cornwall;—Dr. G. Plarr, De quelques Transformations de la Somme $\underset{0}{\overset{-\alpha}{\Sigma^{t}}} \frac{a^{t|+1}\beta^{t|+1}\delta^{t|+1}}{1^{t+1}\gamma^{t+1}\epsilon^{t+1}}$, α étant entier négatif, et de quelques cas dans lesquels cette somme est exprimable par une combinaison de factorielles, la notation $a^{t|+1}$ désignant le produit des t facteurs $a\,(a+1)\,(a+2)$ &c....$(a+t-1)$;—G. Dickie, M.D., Report on the Marine Zoology of Strangford Lough, County Down, and corresponding part of the Irish Channel;—Charles Atherton, Suggestions for Statistical Inquiry into the extent to which Mercantile Steam Transport Economy is affected by the Constructive Type of Shipping, as respects the Proportions of Length, Breadth, and Depth;—J. S. Bowerbank, Further Report on the Vitality of the Spongiadæ;—John P. Hodges, M.D., on Flax;—Major-General Sabine, Report of the Committee on the Magnetic Survey of Great Britain;—Rev. Baden Powell, Report on Observations of Luminous Meteors, 1856–57;—C. Vignoles, C.E., on the Adaptation of Suspension Bridges to sustain the passage of Railway Trains;—Professor W. A. Miller, M.D., on Electro-Chemistry;—John Simpson, R.N., Results of Thermometrical Observations made at the 'Plover's' Wintering-place, Point Barrow, latitude 71° 21′ N., long. 156° 17′ W., in 1852–54;—Charles James Hargreave, LL.D., on the Algebraic Couple; and on the Equivalents of Indeterminate Expressions;—Thomas Grubb, Report on the Improvement of Telescope and Equatorial Mountings;—Professor James Buckman, Report on the Experimental Plots in the Botanical Garden of the Royal Agricultural College at Cirencester;—William Fairbairn, on the Resistance of Tubes to Collapse;—George C. Hyndman, Report of the Proceedings of the Belfast Dredging Committee;—Peter W. Barlow, on the Mechanical Effect of combining Girders and Suspension Chains, and a Comparison of the Weight of Metal in Ordinary and Suspension Girders, to produce equal deflections with a given load;—J. Park Harrison, M.A., Evidences of Lunar Influence on Temperature;—Report on the Animal and Vegetable Products imported into Liverpool from the year 1851 to 1855 (inclusive);—Andrew Henderson, Report on the Statistics of Life-boats and Fishing-boats on the Coasts of the United Kingdom.

Together with the Transactions of the Sections, Rev. H. Lloyd's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-EIGHTH MEETING, at Leeds, September 1858, *Published at 20s.*

Contents:—R. Mallet, Fourth Report upon the Facts and Theory of Earthquake Phenomena;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1857–58;—R. H. Meade, on some Points in the Anatomy of the Araneidea or true Spiders, especially on the internal structure of their Spinning Organs;—W. Fairbairn, Report of the Committee on the Patent Laws;—S. Eddy, on the Lead Mining Districts of Yorkshire;—W. Fairbairn, on the

Collapse of Glass Globes and Cylinders;—Dr. E. Perceval Wright and Prof. J. Reay Greene, Report on the Marine Fauna of the South and West Coasts of Ireland;—Prof. J. Thomson, on Experiments on the Measurement of Water by Triangular Notches in Weir Boards;—Major-General Sabine, Report of the Committee on the Magnetic Survey of Great Britain;—Michael Connal and William Keddie, Report on Animal, Vegetable, and Mineral Substances imported from Foreign Countries into the Clyde (including the Ports of Glasgow, Greenock, and Port Glasgow) in the years 1853, 1854, 1855, 1856, and 1857;—Report of the Committee on Shipping Statistics;—Rev. H. Lloyd, D.D., Notice of the Instruments employed in the Magnetic Survey of Ireland, with some of the Results;—Prof. J. R. Kinahan, Report of Dublin Dredging Committee, appointed 1857–58;—Prof. J. R. Kinahan, Report on Crustacea of Dublin District;—Andrew Henderson, on River Steamers, their Form, Construction, and Fittings, with reference to the necessity for improving the present means of Shallow-Water Navigation on the Rivers of British India;—George C. Hyndman, Report of the Belfast Dredging Committee;—Appendix to Mr. Vignoles's paper "On the Adaptation of Suspension Bridges to sustain the passage of Railway Trains;"—Report of the Joint Committee of the Royal Society and the British Association, for procuring a continuance of the Magnetic and Meteorological Observatories;—R. Beckley, Description of a Self-recording Anemometer.

Together with the Transactions of the Sections, Prof. Owen's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-NINTH MEETING, at Aberdeen, September 1859, *Published at* 15*s.*

CONTENTS:—George C. Foster, Preliminary Report on the Recent Progress and Present State of Organic Chemistry;—Professor Buckman, Report on the Growth of Plants in the Garden of the Royal Agricultural College, Cirencester;—Dr. A. Voelcker, Report on Field Experiments and Laboratory Researches on the Constituents of Manures essential to cultivated Crops;—A. Thomson, Esq., of Banchory, Report on the Aberdeen Industrial Feeding Schools;—On the Upper Silurians of Lesmahago, Lanarkshire;—Alphonse Gages, Report on the Results obtained by the Mechanico-Chemical Examination of Rocks and Minerals;—William Fairbairn, Experiments to determine the Efficiency of Continuous and Self-acting Breaks for Railway Trains;—Professor J. R. Kinahan, Report of Dublin Bay Dredging Committee for 1858–59;—Rev. Baden Powell, Report on Observations of Luminous Meteors for 1858–59;—Professor Owen, Report on a Series of Skulls of various Tribes of Mankind inhabiting Nepal, collected, and presented to the British Museum, by Bryan H. Hodgson, Esq., late Resident in Nepal, &c. &c.;—Messrs. Maskelyne, Hadow, Hardwich, and Llewelyn, Report on the Present State of our Knowledge regarding the Photographic Image;—G. C. Hyndman, Report of the Belfast Dredging Committee for 1859;—James Oldham, Continuation of Report of the Progress of Steam Navigation at Hull;—Charles Atherton, Mercantile Steam Transport Economy as affected by the Consumption of Coals;—Warren de la Rue, Report on the present state of Celestial Photography in England;—Professor Owen, on the Orders of Fossil and Recent Reptilia, and their Distribution in Time;—Balfour Stewart, on some Results of the Magnetic Survey of Scotland in the years 1857 and 1858, undertaken, at the request of the British Association, by the late John Welsh, Esq., F.R.S.;—W. Fairbairn, The Patent Laws: Report of Committee on the Patent Laws;—J. Park Harrison, Lunar Influence on the Temperature of the Air;—Balfour Stewart, an Account of the Construction of the Self-recording Magnetographs at present in operation at the Kew Observatory of the British Association;—Prof. H. J. Stephen Smith, Report on the Theory of Numbers, Part I.;—Report of the Committee on Steamship performance;—Report of the Proceedings of the Balloon Committee of the British Association appointed at the Meeting at Leeds;—Prof. William K. Sullivan, Preliminary Report on the Solubility of Salts at Temperatures above 100° Cent., and on the Mutual Action of Salts in Solution.

Together with the Transactions of the Sections, Prince Albert's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTIETH MEETING, at Oxford, June and July 1860, *Published at* 15*s.*

CONTENTS:—James Glaisher, Report on Observations of Luminous Meteors, 1859–60;—J. R. Kinahan, Report of Dublin Bay Dredging Committee;—Rev. J. Anderson, Report on the Excavations in Dura Den;—Professor Buckman, Report on the Experimental Plots in the Botanical Garden of the Royal Agricultural College, Cirencester;—Rev. R. Walker, Report of the Committee on Balloon Ascents;—Prof. W. Thomson, Report of Committee appointed to prepare a Self-recording Atmospheric Electrometer for Kew, and Portable Apparatus for observing Atmospheric Electricity;—William Fairbairn, Experiments to determine the Effect of

Vibratory Action and long-continued Changes of Load upon Wrought-iron Girders;—R. P. Greg, Catalogue of Meteorites and Fireballs, from A.D. 2 to A.D. 1860;—Prof. H. J. S. Smith, Report on the Theory of Numbers, Part II.;—Vice-Admiral Moorsom, on the Performance of Steam-vessels, the Functions of the Screw, and the Relations of its Diameter and Pitch to the Form of the Vessel;—Rev. W. V. Harcourt, Report on the Effects of long-continued Heat, illustrative of Geological Phenomena;—Second Report of the Committee on Steamship Performance;—Interim Report on the Gauging of Water by Triangular Notches;—List of the British Marine Invertebrate Fauna.

Together with the Transactions of the Sections, Lord Wrottesley's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-FIRST MEETING, at Manchester, September 1861, *Published at* £1.

CONTENTS:—James Glaisher, Report on Observations of Luminous Meteors;—Dr. E. Smith, Report on the Action of Prison Diet and Discipline on the Bodily Functions of Prisoners, Part I.;—Charles Atherton, on Freight as affected by Differences in the Dynamic Properties of Steamships;—Warren De la Rue, Report on the Progress of Celestial Photography since the Aberdeen Meeting;—B. Stewart, on the Theory of Exchanges, and its recent extension;—Drs. E. Schunck, R. Angus Smith, and H. E. Roscoe, on the Recent Progress and Present Condition of Manufacturing Chemistry in the South Lancashire District;—Dr. J. Hunt, on Ethno-Climatology; or, the Acclimatization of Man;—Prof. J. Thomson, on Experiments on the Gauging of Water by Triangular Notches;—Dr. A. Voelcker, Report on Field Experiments and Laboratory Researches on the Constituents of Manures essential to cultivated Crops;—Prof. H. Hennessy, Provisional Report on the Present State of our Knowledge respecting the Transmission of Sound-signals during Fogs at Sea;—Dr. P. L. Sclater and F. von Hochstetter, Report on the Present State of our Knowledge of the Birds of the Genus *Apteryx* living in New Zealand;—J. G. Jeffreys, Report of the Results of Deep-sea Dredging in Zetland, with a Notice of several Species of Mollusca new to Science or to the British Isles;—Prof. J. Phillips, Contributions to a Report on the Physical Aspect of the Moon;—W. R. Birt, Contribution to a Report on the Physical Aspect of the Moon;—Dr. Collingwood and Mr. Byerley, Preliminary Report of the Dredging Committee of the Mersey and Dee;—Third Report of the Committee on Steamship Performance;—J. G. Jeffreys, Preliminary Report on the Best Mode of preventing the Ravages of *Teredo* and other Animals in our Ships and Harbours;—R. Mallet, Report on the Experiments made at Holyhead to ascertain the Transit-Velocity of Waves, analogous to Earthquake Waves, through the local Rock Formations;—T. Dobson, on the Explosions in British Coal-Mines during the year 1859;—J. Oldham, Continuation of Report on Steam Navigation at Hull;—Professor G. Dickie, Brief Summary of a Report on the Flora of the North of Ireland;—Professor Owen, on the Psychical and Physical Characters of the Mincopies, or Natives of the Andaman Islands, and on the Relations thereby indicated to other Races of Mankind;—Colonel Sykes, Report of the Balloon Committee;—Major-General Sabine, Report on the Repetition of the Magnetic Survey of England;—Interim Report of the Committee for Dredging on the North and East Coasts of Scotland;—W. Fairbairn, on the Resistance of Iron Plates to Statical Pressure and the Force of Impact by Projectiles at High Velocities;—W. Fairbairn, Continuation of Report to determine the effect of Vibratory Action and long-continued Changes of Load upon Wrought-Iron Girders;—Report of the Committee on the Law of Patents;—Prof. H. J. S. Smith, Report on the Theory of Numbers, Part III.

Together with the Transactions of the Sections, Mr. Fairbairn's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-SECOND MEETING, at Cambridge, October 1862, *Published at* £1.

CONTENTS:—James Glaisher, Report on Observations of Luminous Meteors, 1861–62;—G. B. Airy, on the Strains in the Interior of Beams;—Archibald Smith and F. J. Evans, Report on the three Reports of the Liverpool Compass Committee;—Report on Tidal Observations on the Humber;—T. Aston, on Rifled Guns and Projectiles adapted for Attacking Armour-plate Defences;—Extracts, relating to the Observatory at Kew, from a Report presented to the Portuguese Government, by Dr. J. A. de Souza;—H. T. Mennell, Report on the Dredging of the Northumberland Coast and Dogger Bank;—Dr. Cuthbert Collingwood, Report upon the best means of advancing Science through the agency of the Mercantile Marine;—Messrs. Williamson, Wheatstone, Thomson, Miller, Matthiessen, and Jenkin, Provisional Report on Standards of Electrical Resistance;—Preliminary Report of the Committee for investigating the Chemical and Mineralogical Composition of the Granites of Do-

negal;—Prof. H. Hennessy, on the Vertical Movements of the Atmosphere considered in connexion with Storms and Changes of Weather;—Report of Committee on the application of Gauss's General Theory of Terrestrial Magnetism to the Magnetic Variations;—Fleeming Jenkin, on Thermo-electric Currents in Circuits of one Metal;—W. Fairbairn, on the Mechanical Properties of Iron Projectiles at High Velocities;—A. Cayley, Report on the Progress of the Solution of certain Special Problems of Dynamics;—Prof. G. G. Stokes, Report on Double Refraction;—Fourth Report of the Committee on Steamship Performance;—G. J. Symons, on the Fall of Rain in the British Isles in 1860 and 1861;—J. Ball, on Thermometric Observations in the Alps;—J. G. Jeffreys, Report of the Committee for Dredging on the N. and E. Coasts of Scotland;—Report of the Committee on Technical and Scientific Evidence in Courts of Law;—James Glaisher, Account of Eight Balloon Ascents in 1862;—Prof. H. J. S. Smith, Report on the Theory of Numbers, Part IV.

Together with the Transactions of the Sections, the Rev. Prof. R. Willis's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-THIRD MEETING, at Newcastle-upon-Tyne, August and September 1863, *Published at £1 5s.*

CONTENTS:—Report of the Committee on the Application of Gun-cotton to Warlike Purposes;—A. Matthiessen, Report on the Chemical Nature of Alloys;—Report of the Committee on the Chemical and Mineralogical Constitution of the Granites of Donegal, and of the Rocks associated with them;—J. G. Jeffreys, Report of the Committee appointed for Exploring the Coasts of Shetland by means of the Dredge;—G. D. Gibb, Report on the Physiological Effects of the Bromide of Ammonium;—C. K. Aken, on the Transmutation of Spectral Rays, Part I.;—Dr. Robinson, Report of the Committee on Fog Signals;—Report of the Committee on Standards of Electrical Resistance;—E. Smith, Abstract of Report by the Indian Government on the Foods used by the Free and Jail Populations in India;—A. Gages, Synthetical Researches on the Formation of Minerals, &c.;—R. Mallet, Preliminary Report on the Experimental Determination of the Temperatures of Volcanic Foci, and of the Temperature, State of Saturation, and Velocity of the issuing Gases and Vapours;—Report of the Committee on Observations of Luminous Meteors;—Fifth Report of the Committee on Steamship Performance;—G. J. Allman, Report on the Present State of our Knowledge of the Reproductive System in the Hydroida;—J. Glaisher, Account of Five Balloon Ascents made in 1863;—P. P. Carpenter, Supplementary Report on the Present State of our Knowledge with regard to the Mollusca of the West Coast of North America;—Professor Airy, Report on Steam-boiler Explosions;—C. W. Siemens, Observations on the Electrical Resistance and Electrification of some Insulating Materials under Pressures up to 300 Atmospheres;—C. M. Palmer, on the Construction of Iron Ships and the Progress of Iron Shipbuilding on the Tyne, Wear, and Tees;—Messrs. Richardson, Stevenson, and Clapham, on the Chemical Manufactures of the Northern Districts;—Messrs. Sopwith and Richardson, on the Local Manufacture of Lead, Copper, Zinc, Antimony, &c.;—Messrs. Daglish and Forster, on the Magnesian Limestone of Durham;—I. L. Bell, on the Manufacture of Iron in connexion with the Northumberland and Durham Coal-field;—T. Spencer, on the Manufacture of Steel in the Northern District;—H. J. S. Smith, Report on the Theory of Numbers, Part V.

Together with the Transactions of the Sections, Sir William Armstrong's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-FOURTH MEETING, at Bath, September 1864, *Published* at 18*s*.

CONTENTS:—Report of the Committee for Observations of Luminous Meteors;—Report of the Committee on the best means of providing for a Uniformity of Weights and Measures;—T. S. Cobbold, Report of Experiments respecting the Development and Migration of the Entozoa;—B. W. Richardson, Report on the Physiological Action of Nitrite of Amyl;—J. Oldham, Report of the Committee on Tidal Observations;—G. S. Brady, Report on deep-sea Dredging on the Coasts of Northumberland and Durham in 1864;—J. Glaisher, Account of Nine Balloon Ascents made in 1863 and 1864;—J. G. Jeffreys, Further Report on Shetland Dredgings;—Report of the Committee on the Distribution of the Organic Remains of the North Staffordshire Coal-field;—Report of the Committee on Standards of Electrical Resistance;—G. J. Symons, on the Fall of Rain in the British Isles in 1862 and 1863;—W. Fairbairn, Preliminary Investigation of the Mechanical Properties of the proposed Atlantic Cable.

Together with the Transactions of the Sections, Sir Charles Lyell's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-FIFTH MEETING, at Birmingham, September 1865, *Published at* £1 5*s.*

CONTENTS:—J. G. Jeffreys, Report on Dredging among the Channel Isles;—F. Buckland, Report on the Cultivation of Oysters by Natural and Artificial Methods;—Report of the Committee for exploring Kent's Cavern;—Report of the Committee on Zoological Nomenclature;—Report on the Distribution of the Organic Remains of the North Staffordshire Coal-field;—Report on the Marine Fauna and Flora of the South Coast of Devon and Cornwall;—Interim Report on the Resistance of Water to Floating and Immersed Bodies;—Report on Observations of Luminous Meteors;—Report on Dredging on the Coast of Aberdeenshire;—J. Glaisher, Account of Three Balloon Ascents;—Interim Report on the Transmission of Sound under Water;—G. J. Symons, on the Rainfall of the British Isles;—W. Fairbairn, on the Strength of Materials considered in relation to the Construction of Iron Ships;—Report of the Gun-Cotton Committee;—A. F. Osler, on the Horary and Diurnal Variations in the Direction and Motion of the Air at Wrottesley, Liverpool, and Birmingham;—B. W. Richardson, Second Report on the Physiological Action of certain of the Amyl Compounds;—Report on further Researches in the Lingula-flags of South Wales;—Report of the Lunar Committee for Mapping the Surface of the Moon;—Report on Standards of Electrical Resistance;—Report of the Committee appointed to communicate with the Russian Government respecting Magnetical Observations at Tiflis;—Appendix to Report on the Distribution of the Vertebrate Remains from the North Staffordshire Coal-field;—H. Woodward, First Report on the Structure and Classification of the Fossil Crustacea;—H. J. S. Smith, Report on the Theory of Numbers, Part VI.;—Report on the best means of providing for a Uniformity of Weights and Measures, with reference to the interests of Science;—A. G. Findlay, on the Bed of the Ocean;—Professor A. W. Williamson, on the Composition of Gases evolved by the Bath Spring called King's Bath.

Together with the Transactions of the Sections, Professor Phillips's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-SIXTH MEETING, at Nottingham, August 1866, *Published at* £1 4*s.*

CONTENTS:—Second Report on Kent's Cavern, Devonshire;—A. Matthiessen, Preliminary Report on the Chemical Nature of Cast Iron;—Report on Observations of Luminous Meteors;—W. S. Mitchell, Report on the Alum Bay Leaf-bed;—Report on the Resistance of Water to Floating and Immersed Bodies;—Dr. Norris, Report on Muscular Irritability;—Dr. Richardson, Report on the Physiological Action of certain compounds of Amyl and Ethyl;—H. Woodward, Second Report on the Structure and Classification of the Fossil Crustacea;—Second Report on the "Menevian Group," and the other Formations at St. David's, Pembrokeshire;—J. G. Jeffreys, Report on Dredging among the Hebrides;—Rev. A. M. Norman, Report on the Coasts of the Hebrides, Part II.;—J. Alder, Notices of some Invertebrata, in connexion with Mr. Jeffreys's Report;—G. S. Brady, Report on the *Ostracoda* dredged amongst the Hebrides;—Report on Dredging in the Moray Firth;—Report on the Transmission of Sound-Signals under Water;—Report of the Lunar Committee;—Report of the Rainfall Committee;—Report on the best means of providing for a Uniformity of Weights and Measures, with reference to the Interests of Science;—J. Glaisher, Account of Three Balloon Ascents;—Report on the Extinct Birds of the Mascarene Islands;—Report on the penetration of Iron-clad Ships by Steel Shot;—J. A. Wanklyn, Report on Isomerism among the Alcohols;—Report on Scientific Evidence in Courts of Law;—A. L. Adams, Second Report on Maltese Fossiliferous Caves, &c.

Together with the Transactions of the Sections, Mr. Grove's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-SEVENTH MEETING, at Dundee, September 1867, *Published at* £1 6*s.*

CONTENTS:—Report of the Committee for Mapping the Surface of the Moon;—Third Report on Kent's Cavern, Devonshire;—On the present State of the Manufacture of Iron in Great Britain;—Third Report on the Structure and Classification of the Fossil Crustacea;—Report on the Physiological Action of the Methyl Compounds;—Preliminary Report on the Exploration of the Plant-Beds of North Greenland;—Report of the Steamship Performance Committee;—On the Meteorology of Port Louis in the Island of Mauritius;—On the Construction and Works of the Highland Railway;—Experimental Researches on the Me-

chanical Properties of Steel;—Report on the Marine Fauna and Flora of the South Coast of Devon and Cornwall;—Supplement to a Report on the Extinct Didine Birds of the Mascarene Islands;—Report on Observations of Luminous Meteors;—Fourth Report on Dredging among the Shetland Isles;—Preliminary Report on the Crustacea, &c., procured by the Shetland Dredging Committee in 1867;—Report on the Foraminifera obtained in the Shetland Seas;—Second Report of the Rainfall Committee;—Report on the best means of providing for a Uniformity of Weights and Measures, with reference to the Interests of Science;—Report on Standards of Electrical Resistance.

Together with the Transactions of the Sections, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-EIGHTH MEETING, at Norwich, August 1868, *Published at* £1 5*s*.

CONTENTS:—Report of the Lunar Committee;—Fourth Report on Kent's Cavern, Devonshire;—On Puddling Iron;—Fourth Report on the Structure and Classification of the Fossil Crustacea;—Report on British Fossil Corals;—Report on Spectroscopic Investigations of Animal Substances;—Report of Steamship Performance Committee;—Spectrum Analysis of the Heavenly Bodies;—On Stellar Spectrometry;—Report on the Physiological Action of the Methyl and allied Compounds;—Report on the Action of Mercury on the Biliary Secretion;—Last Report on Dredging among the Shetland Isles;—Reports on the Crustacea, &c., and on the Annelida and Foraminifera from the Shetland Dredgings;—Report on the Chemical Nature of Cast Iron, Part I.;—Interim Report on the Safety of Merchant Ships and their Passengers;—Report on Observations of Luminous Meteors;—Preliminary Report on Mineral Veins containing Organic Remains;—Report on the desirability of Explorations between India and China;—Report of Rainfall Committee;—Report on Synthetical Researches on Organic Acids;—Report on Uniformity of Weights and Measures;—Report of the Committee on Tidal Observations;—Report of the Committee on Underground Temperature;—Changes of the Moon's Surface;—Report on Polyatomic Cyanides.

Together with the Transactions of the Sections, Dr. Hooker's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-NINTH MEETING, at Exeter, August 1869, *Published* at £1 2*s*.

CONTENTS:—Report on the Plant-beds of North Greenland;—Report on the existing knowledge on the Stability, Propulsion, and Sea-going Qualities of Ships;—Report on Steam-boiler Explosions;—Preliminary Report on the Determination of the Gases existing in Solution in Well-waters;—The Pressure of Taxation on Real Property;—On the Chemical Reactions of Light discovered by Prof. Tyndall;—On Fossils obtained at Kiltorkan Quarry, co. Kilkenny;—Report of the Lunar Committee;—Report on the Chemical Nature of Cast Iron;—Report on the Marine Fauna and Flora of the south coast of Devon and Cornwall;—Report on the Practicability of establishing "a Close Time" for the Protection of Indigenous Animals;—Experimental Researches on the Mechanical Properties of Steel;—Second Report on British Fossil Corals;—Report of the Committee appointed to get cut and prepared Sections of Mountain-limestone Corals for Photographing;—Report on the rate of Increase of Underground Temperature;—Fifth Report on Kent's Cavern, Devonshire;—Report on the Connexion between Chemical Constitution and Physiological Action;—On Emission, Absorption, and Reflection of Obscure Heat;—Report on Observations of Luminous Meteors;—Report on Uniformity of Weights and Measures;—Report on the Treatment and Utilization of Sewage;—Supplement to Second Report of the Steamship-Performance Committee;—Report on Recent Progress in Elliptic and Hyperelliptic Functions;—Report on Mineral Veins in Carboniferous Limestone and their Organic Contents;—Notes on the Foraminifera of Mineral Veins and the Adjacent Strata;—Report of the Rainfall Committee;—Interim Report on the Laws of the Flow and Action of Water containing Solid Matter in Suspension;—Interim Report on Agricultural Machinery;—Report on the Physiological Action of Methyl and Allied Series;—On the Influence of Form considered in Relation to the Strength of Railway-axles and other portions of Machinery subjected to Rapid Alterations of Strain;—On the Penetration of Armour-plates with Long Shells of Large Capacity fired obliquely;—Report on Standardsof Electrical Resistance.

Together with the Transactions of the Sections, Prof. Stokes's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FORTIETH MEETING, at Liverpool, September 1870, *Published at* 18*s*.

CONTENTS:—Report on Steam-boiler Explosions;—Report of the Committee on the Hæmatite Iron-ores of Great Britain and Ireland;—Report on the Sedimentary Deposits of the River Onny;—Report on the Chemical Nature of Cast Iron;—Report on the practicability of establishing "A Close Time" for the protection of Indigenous Animals;—Report on Standards of Electrical Resistance;—Sixth Report on Kent's Cavern;—Third Report on Underground Temperature;—Second Report of the Committee appointed to get cut and prepared Sections of Mountain-Limestone Corals;—Second Report on the Stability, Propulsion, and Sea-going Qualities of Ships;—Report on Earthquakes in Scotland;—Report on the Treatment and Utilization of Sewage;—Report on Observations of Luminous Meteors, 1869–70;—Report on Recent Progress in Elliptic and Hyperelliptic Functions;—Report on Tidal Observations;—On a new Steam-power Meter;—Report on the Action of the Methyl and Allied Series;—Report of the Rainfall Committee;—Report on the Heat generated in the Blood in the process of Arterialization;—Report on the best means of providing for Uniformity of Weights and Measures.

Together with the Transactions of the Sections, Prof. Huxley's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FORTY-FIRST MEETING, at Edinburgh, August 1871, *Published at* 16*s*.

CONTENTS:—Seventh Report on Kent's Cavern;—Fourth Report on Underground Temperature;—Report on Observations of Luminous Meteors, 1870–71;—Fifth Report on the Structure and Classification of the Fossil Crustacea;—Report for the purpose of urging on Her Majesty's Government the expediency of arranging and tabulating the results of the approaching Census in the three several parts of the United Kingdom in such a manner as to admit of ready and effective comparison;—Report for the purpose of Superintending the publication of Abstracts of Chemical papers;—Report of the Committee for discussing Observations of Lunar Objects suspected of change;—Second Provisional Report on the Thermal Conductivity of Metals;—Report on the Rainfall of the British Isles;—Third Report on the British Fossil Corals;—Report on the Heat generated in the Blood during the process of Arterialization;—Report of the Committee appointed to consider the subject of physiological Experimentation;—Report on the Physiological Action of Organic Chemical Compounds;—Report of the Committee appointed to get cut and prepared Sections of Mountain-Limestone Corals;—Second Report on Steam-Boiler Explosions;—Report on the Treatment and Utilization of Sewage;—Report on promoting the Foundation of Zoological Stations in different parts of the World;—Preliminary Report on the Thermal Equivalents of the Oxides of Chlorine;—Report on the practicability of establishing a "Close Time" for the protection of Indigenous Animals;—Report on Earthquakes in Scotland; Report on the best means of providing for a Uniformity of Weights and Measures;—Report on Tidal Observations.

Together with the Transactions of the Sections, Sir William Thomson's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FORTY-SECOND MEETING, at Brighton, August 1872, *Published at* £1 4*s*.

CONTENTS:—Report on the Gaussian Constants for the Year 1829;—Second Supplementary Report on the Extinct Birds of the Mascarene Islands;—Report of the Committee for Superintending the Monthly Reports of the Progress of Chemistry;—Report of the Committee on the best means of providing for a Uniformity of Weights and Measures;—Eighth Report on Kent's Cavern;—Report on promoting the Foundation of Zoological Stations in different parts of the World;—Fourth Report on the Fauna of South Devon;—Preliminary Report of the Committee appointed to Construct and Print Catalogues of Spectral Rays arranged upon a Scale of Wave-numbers;—Third Report on Steam-Boiler Explosions;—Report on Observations of Luminous Meteors, 1871–72;—Experiments on the Surface-friction experienced by a Plane moving through water;—Report of the Committee on the Antagonism between the Action of Active Substances;—Fifth Report on Underground Temperature;—Preliminary Report of the Committee on Siemens's Electrical-Resistance Pyrometer;—Fourth Report on the Treatment and Utilization of Sewage;—Interim Report of the Committee on Instruments for Measuring the Speed of Ships and Currents;—Report on the Rainfall of the British Isles;—Report of the Committee on a Geographical Exploration of the Country of Moab;—Sur l'élimination des Fonctions Arbitraires;—Report on the

Discovery of Fossils in certain remote parts of the North-western Highlands;—Report of the Committee on Earthquakes in Scotland;—Fourth Report on Carboniferous-Limestone Corals;—Report of the Committee to consider the mode in which new Inventions and Claims for Reward in respect of adopted Inventions are examined and dealt with by the different Departments of Government;—Report of the Committee for discussing Observations of Lunar Objects suspected of change;—Report on the Mollusca of Europe;—Report of the Committee for investigating the Chemical Constitution and Optical Properties of Essential Oils;—Report on the practicability of establishing a "Close Time" for the preservation of indigenous animals;—Sixth Report on the Structure and Classification of Fossil Crustacea;—Report of the Committee to organize an Expedition for observing the Solar Eclipse of Dec. 12, 1871; Preliminary Report of a Committee on Terato-embryological Inquiries;—Report on Recent Progress in Elliptic and Hyperelliptic Functions;—Report on Tidal Observations;—On the Brighton Waterworks;—On Amsler's Planimeter.

Together with the Transactions of the Sections, Dr. Carpenter's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FORTY-THIRD MEETING, at Bradford, September, 1873, *Published at £1 5s.*

CONTENTS:—Report of the Committee on Mathematical Tables;—Observations on the Application of Machinery to the cutting of Coal in Mines;—Concluding Report on the Maltese Fossil Elephants;—Report of the Committee for ascertaining the existence in different parts of the United Kingdom of any Erratic Blocks or Boulders;—Fourth Report on Earthquakes in Scotland;—Ninth Report on Kent's Cavern;—On the Flint and Chert Implements found in Kent's Cavern;—Report for investigating the Chemical Constitution and Optical Properties of Essential Oils;—Report of inquiry into the Method of making Gold-assays;—Fifth Report for the Selection and Nomenclature of Dynamical and Electrical Units;—Report of the Committee on the Labyrinthodonts of the Coal-measures;—Report of the Committee to construct and print Catalogues of Spectral Rays;—Report for the purpose of exploring the Settle Caves;—Sixth Report on Underground Temperature;—Report on the Rainfall of the British Isles;—Seventh Report on Researches in Fossil Crustacea;—Report on Recent Progress in Elliptic and Hyperelliptic Functions;—Report on the desirability of establishing a "Close time" for the preservation of indigenous animals;—Report on Luminous Meteors;—On the visibility of the dark side of Venus;—Report of the Committee for the foundation of Zoological Stations in different parts of the world;—Second Report of the Committee for collecting Fossils from North-western Scotland;—Fifth Report on the Treatment and Utilization of Sewage;—Report of the Committee on Monthly Reports of the Progress of Chemistry;—On the Bradford Waterworks;—Report on the possibility of Improving the Methods of Instruction in Elementary Geometry;—Interim Report of the Committee on Instruments for Measuring the Speed of Ships, &c.;—Report of the Committee for Determinating High Temperatures by means of the Refrangibility of Light, evolved by Fluid or Solid Substances;—On a periodicity of Cyclones and Rainfall in connexion with Sun-spot periodicity;—Fifth Report on the Structure of Carboniferous-Limestone Corals;—Report of the Committee on preparing and publishing brief forms of Instructions for Travellers, Ethnologists, &c.;—Preliminary Note from the Committee on the Influence of Forests on the Rainfall;—Report of Sub-Wealden Exploration;—Report of the Committee on Machinery for obtaining a Record of the Roughness of the Sea and Measurement of Waves near shore;—Report on Science-Lectures and Organization;—Second Report on Science-Lectures and Organization.

Together with the Transactions of the Sections, Professor H. J. S. Smith's Address, and Recommendations of the Association and its Committees.

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1863. *ABEL, FREDERICK AUGUSTUS, F.R.S., F.C.S., Director of the Chemical Establishment of the War Department. Royal Arsenal, Woolwich, S.E.
1856. ‡Abercrombie, John, M.D. 13 Suffolk-square, Cheltenham.
1873. ‡Abercrombie, William. 5 Fairmount, Bradford, Yorkshire.
1863. *Abernethy, James. 4 Delahay-street, Westminster, London, S.W.
1873. ‡Abernethy, James. Ferry-hill, Aberdeen.
1860. ‡Abernethy, Robert. Ferry-hill, Aberdeen.
1873. *Abney, Captain, R.E., F.R.A.S., F.C.S. St. Margaret's, Rochester.
1854. ‡Abraham, John. 87 Bold-street, Liverpool.
1873. §Ackroyd, Samuel. Greaves-street, Little Horton, Bradford, Yorkshire.
1869. ‡Acland, Charles T. D. Sprydoncote, Exeter.
*ACLAND, HENRY W. D., M.A., M.D., LL.D., F.R.S., F.R.G.S., Regius Professor of Medicine in the University of Oxford. Broad-street, Oxford.
1860. ‡ACLAND, Sir THOMAS DYKE, Bart., M.A., D.C.L., M.P. Sprydoncote, Exeter; and Athenæum Club, London, S.W.
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1871. §Adams, John R. 15 Old Jewry Chambers, London, E.C.
1869. *ADAMS, WILLIAM GRYLLS, M.A., F.R.S., F.G.S., Professor of Natural Philosophy and Astronomy in King's College, London. 9 Notting-hill-square, London, W.
1873. §Adams-Acton, John. Margutta House, 103 Marylebone-road, N.W.
ADDERLEY, The Right Hon. Sir CHARLES BOWYER, M.P. Hams-hall Coleshill, Warwickshire.
Adelaide, Augustus Short, D.D., Bishop of. South Australia.
1860. *Adie, Patrick. Grove Cottage, Barnes, London, S.W.
1865. *Adkins, Henry. The Firs, Edgbaston, Birmingham.
1845. ‡Ainslie, Rev. G., D.D., Master of Pembroke College. Pembroke Lodge, Cambridge.
1864. *Ainsworth, David. The Flosh, Cleator, Whitehaven.
1871. *Ainsworth, John Stirling. The Flosh, Cleator, Whitehaven.
Ainsworth, Peter. Smithills Hall, Bolton.
1842. *Ainsworth, Thomas. The Flosh, Cleator, Whitehaven.
1871. ‡Ainsworth, William M. The Flosh, Cleator, Whitehaven.
1859. ‡AIRLIE, The Right Hon. the Earl of, K.T. Holly Lodge, Campden Hill, London, W.; and Airlie Castle, Forfarshire.
AIRY, Sir GEORGE BIDDELL, K.C.B., M.A., LL.D., D.C.L., F.R.S., F.R.A.S., Astronomer Royal. The Royal Observatory, Greenwich, S.E.
1871. §Aitken, John. Darroch, Falkirk, N.B.
Akroyd, Edward. Bankfield, Halifax.
1862. ‡ALCOCK, Sir RUTHERFORD, K.C.B. The Athenæum Club, Pall Mall, London, S.W.
1861. ‡Alcock, Thomas, M.D. Side Brook, Salemoor, Manchester.
1872. *Alcock, Thomas, M.D. Oakfield, Ashton-on-Mersey, Manchester.
*Aldam, William. Frickley Hall, near Doncaster.
ALDERSON, Sir JAMES, M.A., M.D., D.C.L., F.R.S., Consulting Physician to St. Mary's Hospital. 17 Berkeley-square, London, W.
1857. ‡Aldridge, John, M.D. 20 Ranelagh-road, Dublin.
1859. ‡ALEXANDER, Major-General Sir JAMES EDWARD, C.B., K.C.L.S., F.R.A.S., F.R.G.S., F.R.S.E. Westerton, Bridge of Allan, N.B.
1873. ‡Alexander, Reginald, M.D. 13 Hallfield-road, Bradford, Yorkshire.
1858. ‡ALEXANDER, WILLIAM, M.D. Halifax.
1850. ‡Alexander, Rev. William Lindsay, D.D., F.R.S.E. Pinkieburn, Musselburgh, by Edinburgh.
1867. ‡Alison, George L. C. Dundee.
1863. ‡*Allan, Miss.*
1859. ‡Allan, Alexander. Scottish Central Railway, Perth.
1871. ‡Allan, G., C.E. 17 Leadenhall-street, London, E.C.
Allan, William.
1871. §Allen, Alfred H., F.C.S. 1 Surrey-street, Sheffield.
1861. ‡Allen, Richard. Didsbury, near Manchester.
Allen, William. 50 Henry-street, Dublin.
1852. *ALLEN, WILLIAM J. C., Secretary to the Royal Belfast Academical Institution. Ulster Bank, Belfast.
1863. ‡Allhusen, C. Elswick Hall, Newcastle-on-Tyne.
*Allis, Thomas, F.L.S. Osbaldwick Hall, near York.
*ALLMAN, GEORGE J., M.D., F.R.S.L.&E., M.R.I.A., F.L.S., Emeritus Professor of Natural History in the University of Edinburgh. 21 Marlborough-road, London, N.W.; and Athenæum Club, London, S.W.
1844. *Ambler, Henry. Watkinson Hall, near Halifax.
1873. §Ambler, John. North-park-road, Bradford, Yorkshire.

Year of Election.

1850. ‡Anderson, Charles William. Cleadon, South Shields.
1871. *Anderson, James. Battlefield House, Langside, Glasgow.
1852. ‡*Anderson, Sir James.*
1850. ‡Anderson, John. 31 St. Bernard's-crescent, Edinburgh.
1874. §Anderson, John, J.P. Holywood, Belfast.
1859. ‡ANDERSON, PATRICK. 15 King-street, Dundee.
1870. ‡Anderson, Thomas Darnley. West Dingle, Liverpool.
1853. *Anderson, William (Yr.). 2 Lennox-street, Edinburgh.
*ANDREWS, THOMAS, M.D., LL.D., F.R.S., Hon. F.R.S.E., M.R.I.A., Vice-President and Professor of Chemistry, Queen's College, Belfast. Queen's College, Belfast.
1857. ‡Andrews, William. The Hill, Monkstown, Co. Dublin.
1859. ‡Angus, John. Town House, Aberdeen.
*ANSTED, DAVID THOMAS, M.A., F.R.S., F.G.S., F.R.G.S. 4 Westminster Chambers, Westminster, S.W.; and Melton, Suffolk.
Anthony, John, M.D. Caius College, Cambridge.
APJOHN, JAMES, M.D., F.R.S., M.R.I.A., Professor of Mineralogy at Dublin University. South Hill, Blackrock, Co. Dublin.
1863. ‡Appleby, C. J. Emerson-street, Bankside, Southwark, London, S.E.
1870. ‡Archer, Francis, jun. 3 Brunswick-street, Liverpool.
1855. *ARCHER, Professor THOMAS C., F.R.S.E., Director of the Museum of Science and Art. West Newington House, Edinburgh.
1874. §Archer, William. St. Brendau's, Grosvenor-road East, Rathmines, Dublin.
1851. ‡ARGYLL, His Grace the Duke of, K.T., LL.D., F.R.S. L. & E., F.G.S. Argyll Lodge, Kensington, London, W.; and Inverary, Argyleshire.
1865. ‡Armitage, J. W., M.D. 9 Huntriss-row, Scarborough.
1861. §Armitage, William. 7 Meal-street, Mosley-street, Manchester.
1867. *Armitstead, George. Errol Park, Errol, N.B.
1873. §Armstrong, Henry E., Ph.D., F.C.S. London Institution, Finsbury-circus, E.C.
1874. §Armstrong, James T., F.C.S. 17 The Willows, Breck-road, Liverpool.
Armstrong, Thomas. Higher Broughton, Manchester.
1857. *ARMSTRONG, Sir WILLIAM GEORGE, C.B., LL.D., D.C.L., F.R.S. 8 Great George-street, London, S.W.; and Elswick Works, Newcastle-upon-Tyne.
1868. ‡Arnold, Edward, F.C.S. Prince of Wales-road, Norwich.
1871. ‡Arnot, William, F.C.S. St. Margaret's, Kirkintilloch, N.B.
1870. §Arnott, Thomas Reid. Bramshill, Harlesden Green, N.W.
1853. *Arthur, Rev. William, M.A. Clapham Common, London, S.W.
1870. *Ash, Dr. T. Linnington. Holsworthy, North Devon.
1874. §Ashe, Isaac, M.B. District Asylum, Londonderry.
1873. §Ashton, John. Gorse Bank House, Windsor-road, Oldham.
1842. *Ashton, Thomas, M.D. 8 Royal Wells-terrace, Cheltenham.
Ashton, Thomas. Ford Bank, Didsbury, Manchester.
1866. ‡Ashwell, Henry. Mount-street, New Basford, Nottingham.
*Ashworth, Edmund. Egerton Hall, Bolton-le-Moors.
Ashworth, Henry. Turton, near Bolton.
1861. ‡Aspland, Alfred. Dukinfield, Ashton-under-Lyne.
Aspland, Algernon Sydney. Glamorgan House, Durdham Down, Bristol.
1861. §Asquith, J. R. Infirmary-street, Leeds.
1861. ‡Aston, Thomas. 4 Elm-court, Temple, London, E.C.
1872. §Atchison, Arthur T. Rose-hill, Dorking.

Year of Election.

1873. ‡Atchison, D. G. Tyersall Hall, Yorkshire.
1858. ‡Atherton, Charles. Sandover, Isle of Wight.
1866. ‡Atherton, J. H., F.C.S. Long-row, Nottingham.
1865. ‡Atkin, Alfred. Griffin's-hill, Birmingham.
1861. ‡Atkin, Eli. Newton Heath, Manchester.
1865. *ATKINSON, EDMUND, F.C.S. 8 The Terrace, York Town, Surrey.
1863. *Atkinson, G. Clayton. 2 Windsor-terrace, Newcastle-on-Tyne.
1858. *Atkinson, John Hastings. 14 East Parade, Leeds.
1842. *Atkinson, Joseph Beavington. Stratford House, 113 Abingdon-road, Kensington, London, W.
1861. ‡Atkinson, Rev. J. A. Longsight Rectory, near Manchester.
1858. Atkinson, William. Claremont, Southport.
1863. *ATTFIELD, Professor J., Ph.D., F.C.S. 17 Bloomsbury-square, London, W.C.
1860. *Austin-Gourlay, Rev. William E. C., M.A. Stoke Abbott Rectory, Beaminster, Dorset.
1865. *Avery, Thomas. Church-road, Edgbaston, Birmingham.
1867. ‡Avison, Thomas, F.S.A. Fulwood Park, Liverpool.
1853. *Ayrton, W. S., F.S.A. Cliffden, Saltburn-by-the-Sea.

*BABINGTON, CHARLES CARDALE, M.A., F.R.S., F.L.S., F.G.S., Professor of Botany in the University of Cambridge. 5 Brookside, Cambridge.
Bache, Rev. Samuel. 74 Beaufort-road, Edgbaston, Birmingham.
Backhouse, Edmund. Darlington.
Backhouse, Thomas James. Sunderland.
1863. ‡Backhouse, T. W. West Hendon House, Sunderland.
1870. §Bailey, Dr. F. J. 51 Grove-street, Liverpool.
1865. ‡Bailey, Samuel, F.G.S. The Peck, Walsall.
1855. ‡Bailey, William. Horseley Fields Chemical Works, Wolverhampton.
1866. ‡Baillon, Andrew. St. Mary's Gate, Nottingham.
1866. ‡Baillon, L. St. Mary's Gate, Nottingham.
1857. ‡BAILY, WILLIAM HELLIER, F.L.S., F.G.S., Acting Palæontologist to the Geological Survey of Ireland. 14 Hume-street; and Apsley Lodge, 92 Rathgar-road, Dublin.
1873. §Bain, James. 3 Park-terrace, Glasgow.
1865. ‡BAIN, Rev. W. J. Glenlark Villa, Leamington.
*Bainbridge, Robert Walton. Middleton House, Middleton-in-Teesdale, by Darlington.
*BAINES, EDWARD. Belgrave-mansions, Grosvenor-gardens, London S.W.; and St. Ann's-hill, Burley, Leeds.
1858. ‡Baines, Frederick. Burley, near Leeds.
1865. ‡BAINES, THOMAS, F.R.G.S. 35 Austen-street, King's Lynn, Norfolk.
1858. ‡Baines, T. Blackburn. 'Mercury' Office, Leeds.
1866. §Baker, Francis B. Sherwood-street, Nottingham.
1858. *Baker, Henry Granville. Bellevue, Horsforth, near Leeds.
1865. ‡Baker, James P. Wolverhampton.
1861. *Baker, John. Gatley-hill, Cheadle, Manchester.
1865. ‡Baker, Robert L. Barham House, Leamington.
1849. *Baker, William. 63 Gloucester-place, Hyde Park, London, W.
1863. §Baker, William. 6 Taptonville, Sheffield.
1860. ‡Balding, James, M.R.C.S. Barkway, Royston, Hertfordshire
1851. **Baldwin, The Hon. Robert.*
1871. ‡Balfour, Francis Maitland. Trinity College, Cambridge.
1871. *Balfour, G. W. Whittinghame, Prestonkirk, Scotland.

Year of
Election.

*BALFOUR, JOHN HUTTON, M.D., M.A., F.R.S. L. & E., F.L.S., Professor of Botany in the University of Edinburgh. 27 Inverleith-row, Edinburgh.
*BALL, JOHN, M.A., F.R.S., F.L.S., M.R.I.A. 10 Southwell-gardens, South Kensington, London, W.
1866. *BALL, ROBERT STAWELL, M.A., LL.D., F.R.S., Andrews Professor of Astronomy in the University of Dublin, and Royal Astronomer. The Observatory, Dunsink, Co. Dublin.
1863. ‡Ball, Thomas. Bramcote, Nottingham.
*Ball, William. Bruce-grove, Tottenham, London, N.; and Glen Rothay, near Ambleside, Westmoreland.
1870. ‡Balmain, William H., F.C.S. Spring Cottage, Great St. Helens, Lancashire.
1869. ‡Bamber, Henry K., F.C.S. 5 Westminster-chambers, Victoria-street, Westminster, S.W.
1874. *Bangay, Frederick Arthur. Cheadle, Cheshire.
1852. ‡Bangor, Viscount. Castleward, Co. Down, Ireland.
1870. ‡BANISTER, Rev. WILLIAM, B.A. St. James's Mount, Liverpool.
1861. ‡Bannerman, James Alexander. Limefield House, Higher Broughton, near Manchester.
1866. ‡Barber, John. Long-row, Nottingham.
1861. *Barbour, George. Kingslee, Farndon, Chester.
1859. ‡Barbour, George F. 11 George-square, Edinburgh.
*Barbour, Robert. Bolesworth Castle, Tattenhall, Chester.
1855. ‡Barclay, Andrew. Kilmarnock, Scotland.
Barclay, Charles, F.S.A., M.R.A.S. Bury-hill, Dorking.
1871. ‡Barclay, George. 17 Coates-crescent, Edinburgh.
Barclay, James. Catrine, Ayrshire.
1852. *Barclay, J. Gurney. 54 Lombard-street, London, E.C.
1860. **Barclay, Robert.*
1868. *Barclay, W. L. 54 Lombard-street, London, E.C.
1863. *Barford, James Gale, F.C.S. Wellington College, Wokingham, Berkshire.
1860. *Barker, Rev. Arthur Alcock, B.D. East Bridgford Rectory, Notts.
1857. ‡Barker, John, M.D., Curator of the Royal College of Surgeons of Ireland. Waterloo-road, Dublin.
1865. ‡Barker, Stephen. 30 Frederick-street, Edgbaston, Birmingham.
1870. ‡BARKLY, Sir HENRY, K.C.B., F.R.S. Governor of Cape Colony and Dependencies. Cape of Good Hope.
1873. ‡Barlow, Crawford, B.A. 2 Old Palace-yard, Westminster, S.W.
Barlow, Lieut.-Col. Maurice (14th Regt. of Foot). 5 Great George-street, Dublin.
Barlow, Peter. 5 Great George-street, Dublin.
1857. ‡BARLOW, PETER WILLIAM, F.R.S., F.G.S. 8 Eliott-place, Blackheath, London, S.E.
1873. ‡BARLOW, W. H., C.E., F.R.S. 2 Old Palace-yard, Westminster, S.W.
1861. *Barnard, Major R. Cary, F.L.S. Bartlow, Leckhampton, Cheltenham.
1868. §Barnes, Richard H. (Care of Messrs. Collyer, 4 Bedford-row, London, W.C.)
Barnes, Thomas Addison. 40 Chester-street, Wrexham.
**Barnett, Richard, M.R.C.S.*
1859. ‡Barr, Major-General, Bombay Army. Culter House, near Aberdeen. (Messrs. Forbes, Forbes & Co., 9 King William-street, London.)

Year of Election.

1861. *Barr, William R., F.G.S. Fernside, Cheadle Hulme, Cheshire.
1860. ‡Barrett, T. B. High-street, Welshpool, Montgomery.
1872. *Barrett, Professor W. F., F.C.S. Royal College of Science, Dublin.
1852. ‡Barrington, Edward. Fassaroe Bray, Co. Wicklow.
1874. §Barrington, R. M. Fassaroe, Bray, Co. Wicklow.
1874. §Barrington-Ward, Mark J., B.A., F.L.S., F.R.G.S. Kenwood, Sheffield.
1866. ‡Barron, William. Elvaston Nurseries, Borrowash, Derby.
1858. ‡Barry, Rev. A., D.D., D.C.L., Principal of King's College, London, W.C.
1862. *Barry, Charles. 15 Pembridge-square, Bayswater, London, W.
Barstow, Thomas. Garrow-hill, near York.
1858. *Bartholomew, Charles. Castle-hill House, Ealing, Middlesex, W.
1855. ‡Bartholomew, Hugh. New Gas-works, Glasgow.
1858. *Bartholomew, William Hamond. Albion Villa, Spencer-place, Leeds.
1873. §Bartley, George C. T. Ealing, Middlesex.
1868. *Barton, Edward (27th Inniskillens). Clonelly, Ireland.
1857. ‡Barton, Folloit W. Clonelly, Co. Fermanagh.
1852. ‡Barton, James. Farndreg, Dundalk.
1864. ‡Bartrum, John S. 41 Gay-street, Bath.
1870. §Baruchson, Arnold. Blundell Sands, near Liverpool.
*Bashforth, Rev. Francis, B.D. Minting Vicarage, near Horncastle.
1861. ‡Bass, John H., F.G.S. 287 Camden-road, London, N.
1866. *Bassett, Henry. 215 Hampstead-road, London, N.W.
1866. ‡Bassett, Richard. Pelham-street, Nottingham.
1869. ‡Bastard, S. S. Summerland-place, Exeter.
1871. ‡Bastian, H. Charlton, M.A., M.D., F.R.S., F.L.S., Professor of Pathological Anatomy at University College Hospital. 20 Queen Anne-street, London, W.
1848. ‡Bate, C. Spence, F.R.S., F.L.S. 8 Mulgrave-place, Plymouth.
1873. *Bateman, Daniel. Low Moor, near Bradford, Yorkshire.
1868. ‡Bateman, Frederick, M.D. Upper St. Giles's-street, Norwich.
Bateman, James, M.A., F.R.S., F.L.S., F.H.S. 9 Hyde Park Gate South, London, W.
1842. *Bateman, John Frederic, C.E., F.R.S., F.G.S. 16 Great George-street, London, S.W.
1864. ‡Bates, Henry Walter, Assist.-Sec. R.G.S., F.L.S. 1 Savile-row, London, W.
1852. ‡Bateson, Sir Robert, Bart. Belvoir Park, Belfast.
1851. ‡Bath and Wells, Lord Arthur Hervey, Lord Bishop of. The Palace, Wells, Somerset.
1863. *Bathurst, Rev. W. H. Lydney Park, Gloucestershire.
1869. ‡Batten, John Winterbotham. 35 Palace-gardens-terrace, Kensington, London, S.W.
1863. §Bauerman, H., F.G.S. 22 Acre-lane, Brixton, London, S.W.
1861. ‡Baxendell, Joseph, F.R.A.S. 108 Stock-street, Manchester.
1867. ‡Baxter, Edward. Hazel Hall, Dundee.
1867. ‡Baxter, John B. Craig Tay House, Dundee.
1870. ‡Baxter, R. Dudley, M.A. 6 Victoria-street, Westminster, S.W.
1867. ‡Baxter, William Edward, M.P. Ashcliffe, Dundee.
1868. ‡Bayes, William, M.D. 58 Brook-street, London, W.
1851. *Bayley, George. 2 Cowper's-court, Cornhill, London, E.C.
1866. †Bayley, Thomas. Lenton, Nottingham.
1854. ‡Baylis, C. O., M.D. 22 Devonshire-road, Claughton, Birkenhead.
Bayly, John. 1 Brunswick-terrace, Plymouth.

Year of Election.

1860. *BEALE, LIONEL S., M.D., F.R.S., Professor of Pathological Anatomy in King's College. 61 Grosvenor-street, London, W.
1861. §Bean, William. Alfreton, Derbyshire.
1872. ‡Beanes, Edward, F.C.S. Avon House, Dulwich Common, Surrey, S.E.
1870. ‡Beard, Rev. Charles. 13 South-hill-road, Toxteth Park, Liverpool.
*Beatson, William. Chemical Works, Rotherham.
1855. *Beaufort, W. Morris, F.R.G.S. Athenæum Club, Pall Mall, London, S.W.
1861. *Beaumont, Rev. Thomas George. Chelmondiston Rectory, Ipswich.
1871. *Beazley, Captain George G. Army and Navy Club, Pall Mall, London, S.W.
1859. *Beck, Joseph, F.R.A.S. 31 Cornhill, London, E.C.
1864. §Becker, Miss Lydia E. Whalley Range, Manchester.
1860. ‡BECKLES, SAMUEL H., F.R.S., F.G.S. 9 Grand-parade, St. Leonard's-on-Sea.
1866. ‡Beddard, James. Derby-road, Nottingham.
1870. §BEDDOE, JOHN, M.D., F.R.S. Clifton, Bristol.
1873. §Behrens, Jacob. Springfield House, North-parade, Bradford.
1865. *BELAVENETZ, I., Captain of the Russian Imperial Navy, F.R.I.G.S., M.S.C.M.A., Superintendent of the Compass Observatory, Cronstadt. (Care of Messrs. Baring Brothers, Bishopsgate-street, London, E.C.)
1847. *BELCHER, Admiral Sir EDWARD, K.C.B., F.R.A.S., F.R.G.S. 13 Dorset-street, Portman-square, London, W.
1874. §Belcher, Richard Boswell. Blockley, Worcestershire.
1873. ‡Bell, A. P. Vicarage, Sowerby Bridge, Yorkshire.
1871. ‡Bell, Archibald. Cleator, Carnforth.
1871. §Bell, Charles B. 6 Spring-bank, Hull.
Bell, Frederick John. Woodlands, near Maldon, Essex.
1859. ‡Bell, George. Windsor-buildings, Dumbarton.
1860. ‡Bell, Rev. George Charles, M.A. Christ's Hospital, London, E.C.
1855. ‡Bell, Capt. Henry. Chalfont Lodge, Cheltenham.
1862. *BELL, ISAAC LOWTHIAN, F.R.S., F.C.S., M.I.C.E. The Hall, Washington, Co. Durham.
1871. *Bell, J. Carter, F.C.S. Kersal Clough, Higher Broughton, Manchester.
1853. ‡Bell, John Pearson, M.D. Waverley House, Hull.
1864. ‡Bell, R. Queen's College, Kingston, Canada.
BELL, THOMAS, F.R.S., F.L.S., F.G.S. The Wakes, Selborne, near Alton, Hants.
1863. *Bell, Thomas. The Minories, Jesmond, Newcastle-on-Tyne.
1867. ‡Bell, Thomas. Belmont, Dundee.
1842. Bellhouse, Edward Taylor. Eagle Foundry, Manchester.
1854. ‡Bellhouse, William Dawson. 1 Park-street, Leeds.
Bellingham, Sir Alan. Castle Bellingham, Ireland.
1866. *BELPER, The Right Hon. Lord, M.A., D.C.L., F.R.S., F.G.S. 75 Eaton-square, London, S.W.; and Kingston Hall, Derby.
1864. *Bendyshe, T. 13 Buckingham-street, Strand, London, W.C.
1870. ‡BENNETT, ALFRED W., M.A., B.Sc., F.L.S. 6 Park Village East, Regent's Park, London, N.W.
1871. ‡Bennett, F. J. 12 Hillmarten-road, Camden-road, London, N.
1870. *Bennett, William. 109 Shaw-street, Liverpool.
1870. *Bennett, William, jun. Oak Hill Park, Old Swan, near Liverpool.
1852. *Bennoch, Francis, F.S.A. 19 Tavistock-square, London, W.C.

Year of Election.

1857. ‡Benson, Charles. 11 Fitzwilliam-square West, Dublin.
Benson, Robert, jun. Fairfield, Manchester.
1848. ‡Benson, Starling, F.G.S. Gloucester-place, Swansea.
1870. ‡Benson, W. Alresford, Hants.
1863. ‡Benson, William. Fourstones Court, Newcastle-on-Tyne.
1848. ‡BENTHAM, GEORGE, F.R.S., F.L.S. 25 Wilton-place, Knightsbridge, London, S.W.
1842. Bentley, John. 9 Portland-place, London, W.
1863. §BENTLEY, ROBERT, F.L.S., Professor of Botany in King's College. 91 Alexandra-road, St. John's-wood, London, N.W.
1875. §Beor, Henry R. 3 Harcourt-buildings, Temple, London, E.C.
1868. ‡BERKELEY, Rev. M. J., M.A., F.L.S. Sibbertoft, Market Harborough.
1863. ‡Berkley, C. Marley Hill, Gateshead, Durham.
1848. ‡Berrington, Arthur V. D. Woodlands Castle, near Swansea.
1866. ‡Berry, Rev. Arthur George. Monyash Parsonage, Bakewell, Derbyshire.
1870. ‡Berwick, George, M.D. 36 Fawcett-street, Sunderland.
1862. ‡Besant, William Henry, M.A., F.R.S. St. John's College, Cambridge.
1865. *BESSEMER, HENRY. Denmark-hill, Camberwell, London, S.E.
1858. ‡Best, William. Leydon-terrace, Leeds.
Bethune, Admiral, C.B., F.R.G.S. Balfour, Fifeshire.
1859. ‡Beveridge, Robert, M.B. 36 King-street, Aberdeen.
1874. *Bevington, James B. Merle Wood, Sevenoaks.
1863. ‡Bewick, Thomas John, F.G.S. Haydon Bridge, Northumberland.
*Bickerdike, Rev. John, M.A. St. Mary's Vicarage, Leeds.
1870. ‡Bickerton, A. W., F.C.S. Hartley Institution, Southampton.
1868. ‡BIDDER, GEORGE PARKER, C.E., F.R.G.S. 24 Great George-street, Westminster, S.W.
1863. ‡Bigger, Benjamin. Gateshead, Durham.
1864. ‡Biggs, Robert. 17 Charles-street, Bath.
1855. ‡Billings, Robert William. 4 St. Mary's-road, Canonbury, London, N.
Bilton, Rev. William, M.A., F.G.S. United University Club, Suffolk-street, London, S.W.; and Chislehurst, Kent.
1842. BINNEY, EDWARD WILLIAM, F.R.S., F.G.S. 40 Cross-street, Manchester.
1873. ‡Binns, J. Arthur. Manningham, Bradford, Yorkshire.
BIRCHALL, EDWIN. Airedale Cliff, Newley, Leeds.
Birchall, Henry. College House, Bradford.
1866. *Birkin, Richard. Aspley Hall, near Nottingham.
*Birks, Rev. Professor Thomas Rawson. 7 Brookside, Cambridge.
1841. *BIRT, WILLIAM RADCLIFF, F.R.A.S. Cynthia-villa, Clarendon-road, Walthamstow, London, N.E.
1871. *BISCHOF, GUSTAV., Professor of Technical Chemistry in the Andersonian University, Glasgow. 234 George-street, Glasgow.
1868. ‡Bishop, John. Thorpe Hamlet, Norwich.
1866. ‡Bishop, Thomas. Bramcote, Nottingham.
1869. ‡Blackall, Thomas. 13 Southernhay, Exeter.
Blackburne, Rev. John, M.A. Yarmouth, Isle of Wight.
Blackburne, Rev. John, jun., M.A. Rectory, Horton, near Chippenham.
1859. ‡Blackie, John Stewart, M.A., Professor of Greek in the University of Edinburgh.
1855. *BLACKIE, W. G., Ph.D., F.R.G.S. 17 Stanhope-terrace, Glasgow.
1870. ‡Blackmore, W. Founder's-court, Lothbury, London, E.C.
*BLACKWALL, Rev. JOHN, F.L.S. Hendre House, near Llanrwst, Denbighshire.
1863. ‡Blake, C. Carter, Ph.D., F.G.S. St. Michael's-buildings, 9 Gracechurch-street, London, E.C.

Year of Election.

1849. *BLAKE, HENRY WOLLASTON, M.A., F.R.S. 8 Devonshire-place, Portland-place, London, W.
1846. *Blake, William. Bridge House, South Petherton, Somerset.
1845. ‡Blakesley, Rev. J. W., B.D. Ware Vicarage, Hertfordshire.
1861. §Blakiston, Matthew. 18 Wilton-crescent, S.W.
*Blakiston, Peyton, M.D., F.R.S. 55 Victoria-street, London, S.W.
1868. ‡BLANC, HENRY, M.D. 9 Bedford-street, Bedford-square, London, W.C.
1869. ‡Blanford, W. T., F.R.S., F.G.S., F.R.G.S., Geological Survey of India, Calcutta. (12 Keppel-street, Russell-square, London, W.C.)
*BLOMEFIELD, Rev. LEONARD, M.A., F.L.S., F.G.S. 19 Belmont, Bath.
Blore, Edward, LL.D., F.R.S., F.S.A. 4 Manchester-square, London, W.
1870. ‡Blundell, Thomas Weld. Ince Blundell Hall, Great Crosby, Lancashire.
1859. ‡Blunt, Sir Charles, Bart. Heathfield Park, Sussex.
1859. ‡Blunt, Capt. Richard. Bretlands, Chertsey, Surrey.
Blyth, B. Hall. 135 George-street, Edinburgh.
1858. *Blythe, William. Church, near Accrington.
1870. ‡Boardman, Edward. Queen-street, Norwich.
1845. ‡*Bodmer, Rodolphe.*
1866. §Bogg, Thomas Wemyss. Louth, Lincolnshire.
1859. *BOHN, HENRY G., F.L.S., F.R.A.S., F.R.G.S., F.S.S. North End House, Twickenham, S.W.
1871. §Bohn, Mrs. North End House, Twickenham, S.W.
1859. ‡Bolster, Rev. Prebendary John A. Cork.
Bolton, R. L. Laurel Mount, Aigburth-road, Liverpool.
1866. ‡Bond, Banks. Low Pavement, Nottingham.
1863. ‡*Bond, Francis T., M.D.*
Bond, Henry John Hayes, M.D. Cambridge.
1871. §Bonney, Rev. Thomas George, M.A., F.S.A., F.G.S. St. John's College, Cambridge.
Bonomi, Ignatius. 36 Blandford-square, London, N.W.
BONOMI, JOSEPH. Soane's Museum, 15 Lincoln's-Inn-fields, London, W.C.
1866. ‡Booker, W. H. Cromwell-terrace, Nottingham.
1861. §Booth, James. Elmfield, Rochdale.
1835. ‡Booth, Rev. James, LL.D., F.R.S., F.R.A.S., F.R.G.S. The Vicarage, Stone, near Aylesbury.
1861. *Booth, William. Hollybank, Cornbrook, Manchester.
1861. *Borchardt, Louis, M.D. Oxford Chambers, Oxford-street, Manchester.
1849. ‡Boreham, William W., F.R.A.S. The Mount, Haverhill, Newmarket.
1863. ‡Borries, Theodore. Lovaine-crescent, Newcastle-on-Tyne.
*Bossey, Francis, M.D. Mayfield, Oxford-road, Redhill, Surrey.
BOSWORTH, Rev. JOSEPH, D.D., LL.D., F.R.S., F.S.A., M.R.I.A., Professor of Anglo-Saxon in the University of Oxford. Oxford.
1867. §Botly, William, F.S.A. Salisbury House, Hamlet-road, Upper Norwood, London, S.E.
1858. ‡Botterill, John. Burley, near Leeds.
1872. ‡Bottle, Alexander. Dover.
1868. ‡Bottle, J. T. 28 Nelson-road, Great Yarmouth.
1871. ‡BOTTOMLEY, JAMES THOMSON, M.A., F.C.S. The College, Glasgow.
Bottomley, William. Forbreda, Belfast.
1850. ‡Bouch, Thomas, C.E. Oxford-terrace, Edinburgh.
1870. ‡Boult, Swinton. 1 Dale-street, Liverpool.
1868. ‡Boulton, W. S. Norwich.
1866. §Bourne, Stephen. Abberley Lodge, Hudstone-drive, Harrow.

Year of Election.

1872. ‡Bovill, William Edward. 29 James-street, Buckingham-gate, London, S.W.
1870. ‡Bower, Anthony. Bowerdale, Seaforth, Liverpool.
1867. ‡Bower, Dr. John. Perth.
1846. *Bowerbank, James Scott, LL.D., F.R.S., F.G.S., F.L.S., F.R.A.S. 2 East-ascent, St. Leonard's-on-Sea.
1856. *Bowlby, Miss F. E. 27 Lansdown-crescent, Cheltenham.
1863. ‡Bowman, R. Benson. Newcastle-on-Tyne.
Bowman, William, F.R.S., F.R.C.S. 5 Clifford-street, London, W.
1869. ‡Bowring, Charles T. Elmsleigh, Princes Park, Liverpool.
1869. ‡Bowring, J. C. Larkbeare, Exeter.
1863. ‡Bowron, James. South Stockton-on-Tees.
1863. §Boyd, Edward Fenwick. Moor House, near Durham.
1871. ‡Boyd, Thomas J. 41 Moray-place, Edinburgh.
1865. ‡Boyle, Rev. G. D. Soho House, Handsworth, Birmingham.
1872. §Brabrook, E. W., F.S.A., Dir. A.I. 28 Abingdon-street, Westminster, S.W.
1869. *Braby, Frederick, F.G.S., F.C.S. Mount Henley, Sydenham Hill, London, S.E.
1870. §Brace, Edmund. 17 Water-street, Liverpool.
Bracebridge, Charles Holt, F.R.G.S. The Hall, Atherstone, Warwickshire.
1861. *Bradshaw, William. Slade House, Levenshulme, Manchester.
1842. *Brady, Sir Antonio, F.G.S. Maryland Point, Stratford, Essex, E.
1857. *Brady, Cheyne, M.R.I.A. Four Courts, Co. Dublin.
Brady, Daniel F., M.D. 5 Gardiner's-row, Dublin.
1863. ‡Brady, George S. 22 Fawcett-street, Sunderland.
1862. §Brady, Henry Bowman, F.R.S., F.L.S., F.G.S. 40 Mosley-street, Newcastle-on-Tyne.
1858. ‡*Brae, Andrew Edmund.*
1864. §Braham, Philip, F.C.S. 6 George-street, Bath.
1870. §Braidwood, Dr. Delemere-terrace, Birkenhead.
1864. §Braikenridge, Rev. George Weare, M.A., F.L.S. Clevedon, Somerset.
1865. §Bramwell, Frederick J., M.I.C.E., F.R.S. 37 Great George-street, London, S.W.
1872. §Bramwell, William J. 17 Prince Albert-street, Brighton.
Brancker, Rev. Thomas, M.A. Limington, Somerset.
1867. ‡Brand, William. Milnefield, Dundee.
1861. *Brandreth, Rev. Henry. Dickleburgh Rectory, Scole, Norfolk.
1852. ‡Brazier, James S., F.C.S., Professor of Chemistry in Marischal College and University of Aberdeen.
1857. ‡Brazill, Thomas. 12 Holles-street, Dublin.
1869. *Breadalbane, The Right Hon. the Earl of. Taymouth Castle, N.B.; and Carlton Club, Pall Mall, London, S.W.
1867. ‡Brechin, The Right Rev. Alexander Penrose Forbes, Lord Bishop of, D.C.L. Castlehill, Dundee.
1873. §Breffit, Edgar. Castleford, near Normanton.
1868. ‡Bremridge, Elias. 17 Bloomsbury-square, London, W.C
1869. ‡Brent, Colonel Robert. Woodbury, Exeter.
1860. ‡Brett, G. Salford.
1866. ‡Brettell, Thomas (Mine Agent). Dudley.
1865. §Brewin, William. Cirencester.
1867. ‡Bridgman, William Kenceley. 69 St. Giles's-street, Norwich.
1870. *Bridson, Joseph R. Belle Isle, Windermere.
1870. ‡Brierley, Joseph, C.E. New Market-street, Blackburn.
1870. *Brigg, John. Broomfield, Keighley, Yorkshire.
1866. *Briggs, Arthur. Cragg Royd, Rawdon, near Leeds.

Year of Election.

*Briggs, General John, F.R.S., M.R.A.S., F.G.S. 2 Tenterden-street, Hanover-square, London, W.
1866. §Briggs, Joseph. Barrow-in-Furness.
1863. *Bright, Sir Charles Tilston, C.E., F.G.S., F.R.G.S., F.R.A.S. 69 Lancaster-gate, W.; and 26 Duke-street, London, S.W.
1870. ‡Bright, H. A., M.A., F.R.G.S. Ashfield, Knotty Ash.
Bright, The Right Hon. John, M.P. Rochdale, Lancashire.
1868. ‡Brine, Commander Lindesay. Army and Navy Club, Pall Mall, London, S.W.
1842. Broadbent, Thomas. Marsden-square, Manchester.
1859. *Brodhurst, Bernard Edward. 20 Grosvenor-street, Grosvenor-square, London, W.
1847. ‡Brodie, Sir Benjamin C., Bart., M.A., D.C.L., F.R.S. Brockham Warren, Reigate.
1834. ‡Brodie, Rev. James, F.G.S. Monimail, Fifeshire.
1865. ‡Brodie, Rev. Peter Bellenger, M.A., F.G.S. Rowington Vicarage, near Warwick.
1853. ‡Bromby, J. H., M.A. The Charter House, Hull.
Bromilow, Henry G. Merton Bank, Southport, Lancashire.
*Brooke, Charles, M.A., F.R.S., Pres. R.M.S. 16 Fitzroy-square, London, W.
1855. ‡Brooke, Edward. Marsden House, Stockport, Cheshire.
1864. *Brooke, Rev. J. Ingham. Thornhill Rectory, Drewsbury.
1855. ‡Brooke, Peter William. Marsden House, Stockport, Cheshire.
1863. §Brooks, John Crosse. Wallsend, Newcastle-on-Tyne.
1846. *Brooks, Thomas. Cranshaw Hall, Rawstenstall, Manchester.
Brooks, William. Ordfall Hill, East Retford, Nottinghamshire.
1874. §Broom, William. 20 Woodlands-terrace, Glasgow.
1847. ‡Broome, C. Edward, F.L.S. Elmhurst, Batheaston, near Bath.
1863. *Brough, Lionel H., F.G.S., one of Her Majesty's Inspectors of Coal-Mines. 11 West-mall, Clifton, Bristol.
*Broun, John Allan, F.R.S., late Astronomer to His Highness the Rajah of Travancore. 34 Reinsburg Strasse, Stuttgart.
1864. ‡Brown, Mrs. 1 Stratton-street, Piccadilly, London, W.
1863. *Brown, Alexander Crum, M.D., F.R.S.E., F.C.S., Professor of Chemistry in the University of Edinbugh. 8 Belgrave-crescent, Edinburgh.
1867. ‡Brown, Charles Gage, M.D. 88 Sloane-street, London, S.W.
1855. ‡Brown, Colin. 3 Mansfield-place, Glasgow.
1871. §Brown, David. 93 Abbey-hill, Edinburgh.
1863. *Brown, Rev. Dixon. Unthank Hall, Haltwhistle, Carlisle.
1865. §Brown, Edwin, F.G.S. Burton-upon-Trent.
1858. §Brown, Henry, J.P., LL.D. Daisy Hill, Rawdon, Leeds.
1870. §Brown, Horace T. The Bank, Burton-on-Trent.
Brown, Hugh. Broadstone, Ayrshire.
1870. §Brown, J. Campbell, D.Sc., F.C.S. Royal Infirmary School of Medicine, Liverpool.
1859. ‡Brown, Rev. John Crombie, LL.D., F.L.S. Berwick-on-Tweed.
1863. ‡*Brown, John H.*
1874. §Brown, John S. Edenderry, Shaw's Bridge, Belfast.
1863. ‡Brown, Ralph. Lambton's Bank, Newcastle-on-Tyne.
1871. ‡Brown, Robert, M.A., Ph.D., F.R.G.S. 4 Gladstone-terrace, Edinburgh.
1868. ‡Brown, Samuel. Grafton House, Swindon, Wilts.
*Brown, Thomas. Gwentland, Chepstow.
*Brown, William. 11 Maiden-terrace, Dartmouth Park, London, N.
1855. ‡Brown, William. 11 Albany-place, Glasgow.

Year of Election.

1850. ‡Brown, William, F.R.S.E. 25 Dublin-street, Edinburgh.
1865. ‡Brown, William. 41A New-street, Birmingham.
1866. *Browne, Rev. J. H. Lowdham Vicarage, Nottingham.
1862. *Browne, Robert Clayton, jun., B.A. Browne's Hill, Carlow, Ireland.
1872. ‡Browne, R. Mackley, F.G.S. Northside, St. John's, Sevenoaks, Kent.
1865. *Browne, William, M.D. The Friary, Lichfield.
1865. §Browning, John, F.R.A.S. 111 Minories, London, E.
1855. §Brownlee, James, jun. 30 Burnbank-gardens, Glasgow.
1853. ‡Brownlow, William B. Villa-place, Hull.
1863. *Brunel, H. M. 23 Delahay-street, Westminster, S.W.
1863. ‡Brunel, J. 23 Delahay-street, Westminster, S.W.
1871. ‡*Brunnöw, F.*
1868. ‡Brunton, T. Lauder, M.D., F.R.S. 23 Somerset-street, Portman-square, London, W.
1861. ‡Bryce, James. York Place, Higher Broughton, Manchester.
BRYCE, JAMES, M.A., LL.D., F.R.S.E., F.G.S. High School, Glasgow, and Bowes Hill, Blantyre, by Glasgow.
BRYCE, Rev. R. J., LL.D., Principal of Belfast Academy. Belfast.
1859. ‡Bryson, William Gillespie. Cullen, Aberdeen.
1867. ‡BUCCLEUCH and QUEENSBERRY, His Grace the Duke of, K.G., D.C.L., F.R.S. L. & E., F.L.S. Whitehall-gardens, London, S.W.; and Dalkeith Palace, Edinburgh.
1871. §BUCHAN, ALEXANDER. 72 Northumberland-street, Edinburgh.
1867. ‡Buchan, Thomas. Strawberry Bank, Dundee.
BUCHANAN, ANDREW, M.D. Professor of the Institutes of Medicine in the University of Glasgow. 4 Ethol-place, Glasgow.
Buchanan, Archibald. Catrine, Ayrshire.
Buchanan, D. C. Poulton cum Seacombe, Cheshire.
1871. ‡Buchanan, John Y. 10 Moray-place, Edinburgh.
1864. §BUCKLE, Rev. GEORGE, M.A. Twerton Vicarage, Bath.
1865. *Buckley, Henry. 27 Wheeley's-road, Edgbaston, Birmingham.
1848. *BUCKMAN, Professor JAMES, F.L.S., F.G.S. Bradford Abbas, Sherbourne, Dorsetshire.
1869. ‡Bucknill, J., M.D., F.R.S. Hillmorton Hall, near Rugby.
1851. *BUCKTON, GEORGE BOWDLER, F.R.S., F.L.S., F.C.S. Weycombe, Haslemere, Surrey.
1848. *BUDD, JAMES PALMER. Ystalyfera Iron Works, Swansea.
1871. §Bulloch, Matthew. 11 Park-circus, Glasgow.
1845. *BUNBURY, Sir CHARLES JAMES FOX, Bart., F.R.S., F.L.S., F.G.S., F.R.G.S. Barton Hall, Bury St. Edmunds.
1865. ‡Bunce, John Mackray. 'Journal Office,' New-street, Birmingham.
1863. ‡Bunning, T. Wood. 34 Grey-street, Newcastle-on-Tyne.
1842. **Burd, John.*
1869. ‡Burdett-Coutts, Baroness. Stratton-street, Piccadilly, London, W.
1874. §Burdon, Henry, M.D. Clandeboye, Belfast.
1872. *Burgess, Herbert. 62 High-street, Battle, Sussex.
1857. ‡*Burk, J. Lardner, LL.D.*
1865. ‡Burke, Luke. 5 Albert-terrace, Acton, London, W.
1869. **Burnell, Arthur Coke.*
1859. ‡Burnett, Newell. Belmont-street, Aberdeen.
1872. §Burrows, Sir John Cordy. 62 Old Steine, Brighton.
1860. ‡Burrows, Montague, M.A., Professor of Modern History, Oxford.
1874. §Burt, Rev. J. T. Broadmoor, Berks.
1866. *BURTON, FREDERICK M., F.G.S. Highfield, Gainsborough.
1864. ‡Bush, W. 7 Circus, Bath

Year of Election.

Bushell, Christopher. Royal Assurance-buildings, Liverpool.
1855. *Busk, George, F.R.S., V.P.L.S., F.G.S., Examiner in Comparative Anatomy in the University of London. 32 Harley-street, Cavendish-square, London, W.
1857. ‡Butt, Isaac, Q.C., M.P. 64 Eccles-street, Dublin.
1855. *Buttery, Alexander W. Monkland Iron and Steel Company, Cardarroch, near Airdrie.
1872. ‡Buxton, Charles Louis. Cromer, Norfolk.
1870. ‡Buxton, David, Principal of the Liverpool Deaf and Dumb Institution, Oxford-street, Liverpool.
1868. ‡Buxton, S. Gurney. Catton Hall, Norwich.
1872. ‡Buxton, Sir T. Fowell. Warlies, Waltham Abbey, Essex.
1854. ‡Byerley, Isaac, F.L.S. Seacombe, Liverpool.
Byng, William Bateman. Orwell Works House, Ipswich.
1852. ‡Byrne, Very Rev. James. Ergenagh Rectory, Omagh.

1858. §Cail, John. Stokesley, Yorkshire.
1863. ‡Cail, Richard. Beaconsfield, Gateshead.
1854. ‡Caine, Nathaniel. 38 Belvedere-road, Princes Park, Liverpool.
1858. *Caine, Rev. William, M.A. Christ Church Rectory, Denton, near Manchester.
1863. ‡Caird, Edward. Finnart, Dumbartonshire.
1861. *Caird, James Key. 8 Magdalene-road, Dundee.
1855. *Caird, James Tennant. Shipyard, Greenock.
1857. ‡Cairnes, Professor. University College, London, W.C.
1868. ‡Caley, A. J. Norwich.
1868. ‡Caley, W. Norwich.
1857. ‡Callan, Rev. N. J., Professor of Natural Philosophy in Maynooth College.
1853. ‡Calver, Captain E. K., R.N., F.R.S. 21 Norfolk-street, Sunderland.
1857. ‡Cameron, Charles A., M.D. 15 Pembroke-road, Dublin.
1870. ‡Cameron, John, M.D. 17 Rodney-street, Liverpool.
1859. ‡Campbell, Rev. C. P., Principal of King's College, Aberdeen.
1857. *Campbell, Dugald, F.C.S. 7 Quality-court, Chancery-lane, London, W.C.
1874. *Campbell, Sir George, K.C.S.I., D.C.L., M.P., F.R.G.S. 13 Cornwall-gardens, South Kensington, London, S.W.; and Edenwood, Cupar, Fife.
Campbell, Sir Hugh P. H., Bart. 10 Hill-street, Berkeley-square, London, W.; and Marchmont House, near Dunse, Berwickshire.
*Campbell, Sir James. 129 Bath-street, Glasgow.
Campbell, John Archibald, M.D., F.R.S.E. Albyn-place, Edinburgh.
1872. §Campbell, Rev. J. R., D.D. 5 Eldon-place, Manningham-lane, Bradford, Yorkshire.
1859. ‡Campbell, William. Dunmore, Argyllshire.
1871. ‡Campbell, William Hunter, LL.D. Georgetown, Demerara, British Guiana. (Messrs. Ridgway & Sons, 2 Waterloo-place, London, S.W.)
Campbell-Johnston, Alexander Robert, F.R.S. 84 St. George's-square, London, S.W.
1862. *Campion, Rev. Dr. William M. Queen's College, Cambridge.
1868. *Cann, William. 9 Southernhay, Exeter.
1873. *Carbutt, Edward Hamer, C.E. 5 Kingston-terrace, Leeds, Yorkshire.
*Carew, William Henry Pole. Antony, Torpoint, Devonport.
Carlisle, Harvey Goodwin, D.D., Lord Bishop of. Carlisle.

Year of
Election.

1861. ‡Carlton, James. Mosley-street, Manchester.
1867. ‡Carmichael, David (Engineer). Dundee.
1867. ‡Carmichael, George. 11 Dudhope-terrace, Dundee.
Carmichael, H.
Carmichael, John T. C. Messrs. Todd & Co., Cork.
1871. §CARPENTER, CHARLES. Brunswick-square, Brighton.
1871. §Carpenter, Herbert P. 56 Regent's Park-road, London, N.W.
*CARPENTER, PHILIP PEARSALL, B.A., Ph.D. Montreal, Canada. (Care of Dr. W. B. Carpenter, 56 Regent's Park-road, London, N.W.)
1854. ‡Carpenter, Rev. R. Lant, B.A. Bridport.
1845. ‡CARPENTER, WILLIAM B., M.D., LL.D., F.R.S., F.L.S., F.G.S., Registrar of the University of London. 56 Regent's Park-road, London, N.W.
1872. §CARPENTER, WILLIAM LANT, B.A., B.Sc., F.C.S. Winifred House, Pembroke-road, Clifton, Bristol.
1842. *Carr, William, M.D., F.L.S., F.R.C.S. Lee Grove, Blackheath, S.E.
1861. *Carrick, Thomas. 5 Clarence-street, Manchester.
1867. §CARRUTHERS, WILLIAM, F.R.S., F.L.S., F.G.S. British Museum, London, W.C.
1861. *Carson, Rev. Joseph, D.D., M.R.I.A. 18 Fitzwilliam-place, Dublin.
1857. ‡CARTE, ALEXANDER, M.D. Royal Dublin Society, Dublin.
1868. §Carteighe, Michael, F.C.S. 172 New Bond-street, London, W.
1866. ‡Carter, H. H. The Park, Nottingham.
1855. ‡Carter, Richard, C.E. Long Carr, Barnsley, Yorkshire.
1870. ‡Carter, Dr. William. 69 Elizabeth-street, Liverpool.
*CARTMELL, Rev. JAMES, D.D., F.G.S., Master of Christ's College. Christ College Lodge, Cambridge.
Cartmell, Joseph, M.D. Carlisle.
1870. §Cartwright, Joshua. 70 King-street, Dukinfield.
1862. ‡Carulla, Facundo, F.A.S.L. Care of Messrs. Daglish and Co., 8 Harrington-street, Liverpool.
1868. ‡Cary, Joseph Henry. Newmarket-road, Norwich.
1866. ‡Casella, L. P., F.R.A.S. South-grove, Highgate, London, N.
1871. §Cash, Joseph. Bird Grove, Coventry.
1873. §Cash, William, Elmfield-terrace, Saville Park, Halifax.
1842. **Cassels, Rev. Andrew, M.A.*
1874. §Caton, Richard, M.D., Lecturer on Physiology at the Liverpool Medical School. 18A Abercromby-square, Liverpool.
1853. ‡Cator, John B., Commander R.N. 1 Adelaide-street, Hull.
1859. ‡Catto, Robert. 44 King-street, Aberdeen.
1866. ‡*Catton, Alfred, R., M.A., F.R.S.E.*
1873. *Cavendish, Lord Frederick, M.P. 21 Carlton House-terrace, London, S.W.
1849. ‡Cawley, Charles Edward. The Heath, Kirsall, Manchester.
1860. §CAYLEY, ARTHUR, LL.D., F.R.S., V.P.R.A.S., Sadlerian Professor of Mathematics in the University of Cambridge. Garden House, Cambridge.
Cayley, Digby. Brompton, near Scarborough.
Cayley, Edward Stillingfleet. Wydale, Malton, Yorkshire.
1871. *Cecil, Lord Sackville. Hayes Common, Beckenham, Kent.
1870. ‡Chadburn, C. H. Lord-street, Liverpool.
1858. *Chadwick, Charles, M.D. 35 Park-square, Leeds.
1860. ‡CHADWICK, DAVID, M.P. 27 Belsize-park, London, N.W.
1842. CHADWICK, EDWIN, C.B. Richmond, Surrey.
1842. Chadwick, Elias, M.A. Pudleston Court, near Leominster.

Year of Election.

1842. Chadwick, John. Broadfield, Rochdale.
1859. ‡Chadwick, Robert. Highbank, Manchester.
1861. ‡Chadwick, Thomas. Wilmslow Grange, Cheshire.
*Challis, Rev. James, M.A., F.R.S., F.R.A.S., Plumian Professor of Astronomy in the University of Cambridge. 2 Trumpington-street, Cambridge.
1859. ‡Chalmers, John Inglis. Aldbar, Aberdeen.
1865. ‡Chamberlain, J. H. Christ Church-buildings, Birmingham.
1868. ‡Chamberlin, Robert. Catton, Norwich.
1842. Chambers, George. High Green, Sheffield.
Chambers, John.
1868. ‡Chambers, W. O. Lowestoft, Suffolk.
*Champney, Henry Nelson. Mount, York.
1865. ‡Chance, A. M. Edgbaston, Birmingham.
1865. *Chance, James T. Four Oaks Park, Sutton Coldfield, Birmingham.
1865. §Chance, Robert Lucas. Chad Hill, Edgbaston, Birmingham.
1861. *Chapman, Edward, M.A., F.L.S., F.C.S. Frewen Hall, Oxford.
1861. *Chapman, John, M.P. Hill End, Mottram, Manchester.
1866. ‡Chapman, William. The Park, Nottingham.
1871. §Chappell, William, F.S.A. Strafford Lodge, Oatlands Park, Weybridge Station.
1874. §Charles, John James, M.A., M.D. 11 Fisherwick-place, Belfast.
1871. ‡Charles, T. C., M.D. Queen's College, Belfast.
1836. Charlesworth, Edward, F.G.S. 113a Strand, London, W.C.
1874. §Charley, William. Seymour Hill, Dunmurry, Ireland.
1863. ‡Charlton, Edward, M.D. 7 Eldon-square, Newcastle-on-Tyne.
1866. ‡Charnock, Richard Stephen, Ph.D., F.S.A., F.R.G.S. 8 Gray's-Inn-square, London, W.C.
Chatto, W. J. P. Union Club, Trafalgar-square, London, S.W.
1867. *Chatwood, Samuel. 5 Wentworth-place, Bolton.
1864. ‡Cheadle, W. B., M.A., M.D., F.R.G.S. 2 Hyde Park-place, Cumberland-gate, London, W.
1874. *Chermside, Lieutenant H. C., R.E. Care of Messrs. Cox & Co., Craig's-court, Charing Cross, London, S.W.
1872. §Chichester, The Right Hon. the Earl of. Stanmer House, Lewes.
Chichester, Richard Durnford, Lord Bishop of. Chichester.
1865. **Child, Gilbert W., M.A., M.D., F.L.S.*
1842. *Chiswell, Thomas. 17 Lincoln-grove, Plymouth-grove, Manchester.
1863. ‡Cholmeley, Rev. C. H. Dinton Rectory, Salisbury.
1859. ‡Christie, John, M.D. 46 School-hill, Aberdeen.
1861. ‡Christie, Professor R. C., M.A. 7 St. James's-square, Manchester.
Christison, Sir Robert, Bart., M.D., D.C.L., F.R.S.E., Professor of Dietetics, Materia Medica, and Pharmacy in the University of Edinburgh. Edinburgh.
1870. §Church, A. H., F.C.S., Professor of Chemistry in the Royal Agricultural College, Cirencester.
1860. ‡*Church, William Selby, M.A.*
1857. ‡Churchill, F., M.D. 15 Stephen's-green, Dublin.
1868. ‡Clabburn, W. H. Thorpe, Norwich.
1863. ‡Clapham, A. 3 Oxford-street, Newcastle-on-Tyne.
1863. ‡Clapham, Henry. 5 Summerhill-grove, Newcastle-on-Tyne.
1855. §Clapham, Robert Calvert. Garsdon House, Garsdon, Newcastle-on-Tyne.
1869. §Clapp, Frederick. 44 Magdalen-street, Exeter.
1857. ‡Clarendon, Frederick Villiers. 1 Belvidere-place, Mountjoy-square, Dublin.
Clark, Courtney K.

Year of Election.

1859. ‡Clark, David. Coupar Angus, Fifeshire.
Clark, G. T. Bombay; and Athenæum Club, London, S.W.
1846. *CLARK, HENRY, M.D. 2 Arundel-gardens, Kensington, London, W.
1861. ‡Clark, Latimer. 5 Westminster-chambers, Victoria-street, London, S.W.
1855. ‡Clark, Rev. William, M.A. Barrhead, near Glasgow.
1865. ‡Clarke, Rev. Charles. Charlotte-road, Edgbaston, Birmingham.
Clarke, George. Mosley-street, Manchester.
1872. *CLARKE, HYDE. 32 St. George's-square, Pimlico, London, S.W.
1861. *Clarke, J. H. Lark Hill House, Edgeley, Stockport.
1842. *Clarke, Joseph.*
1851. ‡CLARKE, JOSHUA, F.L.S. Fairycroft, Saffron Walden.
Clarke, Thomas, M.A. Knedlington Manor, Howden, Yorkshire.
1861. ‡Clay, Charles, M.D. 101 Piccadilly, Manchester.
*Clay, Joseph Travis, F.G.S. Rastrick, near Brighouse, Yorkshire.
1856. *Clay, Colonel William. The Slopes, Wallasea, Cheshire.
1866. ‡Clayden, P. W. 13 Tavistock-square, London, W.C.
1850. ‡CLEGHORN, HUGH, M.D., F.L.S., late Conservator of Forests, Madras. Stravithy, St. Andrews, Scotland.
1859. ‡Cleghorn, John. Wick.
1861. §CLELAND, JOHN, M.D., F.R.S., Professor of Anatomy and Physiology in Queen's College, Galway. Vicarscroft, Galway.
1857. ‡Clements, Henry. Dromin, Listowel, Ireland.
‡Clerk, Rev. D. M. Deverill, Warminster, Wiltshire.
CLERKE, Rev. C. C., D.D., Archdeacon of Oxford and Canon of Christ Church, Oxford. Milton Rectory, Abingdon, Berkshire.
1852. ‡Clibborn, Edward. Royal Irish Academy, Dublin.
1873. §Cliff, John. Halton, Runcorn.
1869. §CLIFFORD, WILLIAM KINGDON, M.A., F.R.S., Professor of Applied Mathematics and Mechanics in University College. 14 Maryland-road, Harrow-road, London, W.
1865. ‡Clift, John E., C.E. Redditch, Bromsgrove, near Birmingham.
1861. *CLIFTON, R. BELLAMY, M.A., F.R.S., F.R.A.S., Professor of Experimental Philosophy in the University of Oxford. Portland Lodge, Park Town, Oxford.
Clonbrock, Lord Robert. Clonbrock, Galway.
1854. ‡Close, The Very Rev. Francis, M.A. Carlisle.
1866. §CLOSE, THOMAS, F.S.A. St. James's-street, Nottingham.
1873. ‡Clough, John. Bracken Bank, Keighley, Yorkshire.
1859. ‡Clouston, Rev. Charles. Sandwick, Orkney.
1861. *Clouston, Peter. 1 Park-terrace, Glasgow.
1863. *Clutterbuck, Thomas. Warkworth, Acklington.
1868. ‡Coaks, J. B. Thorpe, Norwich.
1855. *Coats, Sir Peter. Woodside, Paisley.
1855. *Coats, Thomas. Fergeslie House, Paisley.
Cobb, Edward. 20 Park-street, Bath.
1851. *COBBOLD, JOHN CHEVALLIER. Holywells, Ipswich; and Athenæum Club, London, S.W.
1864. ‡COBBOLD, T. SPENCER, M.D., F.R.S., F.L.S., Lecturer on Zoology and Comparative Anatomy at the Middlesex Hospital. 42 Harley-street, London, W.
1864. *Cochrane, James Henry. 129 Lower Baggot-street, Dublin.
1854. ‡*Cockey, William.*
1861. *Coe, Rev. Charles C., F.R.G.S. Highfield, Manchester-road, Bolton.
1865. ‡Coghill, H. Newcastle-under-Lyme.
1853. ‡Colchester, William, F.G.S. Grundesburgh Hall, Ipswich.
1868. ‡Colchester, W. P. Bassingbourn, Royston.

Year of Election.

1859. *Cole, Henry Warwick, Q.C. 23 High-street, Warwick.
1860. ‡Coleman, J. J., F.C.S. 69 St. George's-place, Glasgow.
1854. *Colfox, William, B.A. Westmead, Bridport, Dorsetshire.
1857. ‡Colles, William, M.D. 21 Stephen's-green, Dublin.
1861. *Collie, Alexander. 12 Kensington Palace-gardens, London, W.
1869. ‡Collier, W. F. Woodtown, Horrabridge, South Devon.
1854. ‡COLLINGWOOD, CUTHBERT, M.A., M.B., F.L.S. 4 Grove-terrace, Belvedere-road, Upper Norwood, Surrey, S.E.
1861. *Collingwood, J. Frederick, F.G.S. Anthropological Institute, 4 St. Martin's-place, London, W.C.
1865. *Collins, James Tertius. 12 Church-road, Edgbaston, Birmingham.
Collis, Stephen Edward. Listowel, Ireland.
1868. *COLMAN, J. J., M.P. Carrow House, Norwich; and 108 Cannon-street, London, E.C.
1870. §Coltart, Robert. The Hollies, Aigburth-road, Liverpool.
Colthurst, John. Clifton, Bristol.
1874. §Combe, James. Ormiston House, Belfast.
*COMPTON, The Rev. Lord ALWYN. Castle Ashby, Northamptonshire; and 145 Piccadilly, London, W.
1846. *Compton, Lord William. 145 Piccadilly, London, W.
1852. ‡Connal, Michael. 16 Lynedock-terrace, Glasgow.
1871. *Connor, Charles C. Hope House, College Park East, Belfast.
1864. *Conwell, Eugene Alfred, M.R.I.A. The Model Schools, Cork.
1863. ‡COOKE, EDWARD WILLIAM, R.A., F.R.S., F.R.G.S., F.L.S., F.G.S. Glen Andred, Groombridge, Sussex; and Athenæum Club, Pall Mall, London, S.W.
1868. ‡Cooke, Rev. George H. The Parsonage, Thorpe, Norwich.
Cooke, James R., M.A. 73 Blessington-street, Dublin.
Cooke, J. B. Cavendish-road, Birkenhead.
1868. §COOKE, M. C., M.A. 2 Grosvenor-villas, Upper Holloway, London, N.
Cooke, Rev. T. L., M.A. Magdalen College, Oxford.
Cooke, Sir William Fothergill. Telegraph Office, Lothbury, London, E.C.
1859. *Cooke, William Henry, M.A., Q.C., F.S.A. 42 Wimpole-street, London, W.; and Rainthorpe Hall, Long Stratton.
1865. ‡Cooksey, Joseph. West Bromwich, Birmingham.
1862. *Cookson, Rev. H. W., D.D. St. Peter's College Lodge, Cambridge.
1863. ‡Cookson, N. C. Benwell Tower, Newcastle-on-Tyne.
1869. §Cooling, Edwin. Mile Ash, Derby.
1850. ‡COOPER, Sir HENRY, M.D. 7 Charlotte-street, Hull.
Cooper, James. 58 Pembridge-villas, Bayswater, London, W.
1868. ‡Cooper, W. J. The Old Palace, Richmond, Surrey.
1846. ‡Cooper, William White. 19 Berkeley-square, London, W.
1871. ‡Copeland, Ralph, Ph.D. Parsonstown, Ireland.
1868. ‡Copeman, Edward, M.D. Upper King-street, Norwich.
1863. ‡Coppin, John. North Shields.
1842. *Corbet, Richard. Bayshill Lawn, Cheltenham.
1842. Corbett, Edward. Ravenoak, Cheadle-hulme, Cheshire.
1855. ‡Corbett, Joseph Henry, M.D., Professor of Anatomy and Physiology, Queen's College, Cork.
1870. *CORFIELD, W. H., M.A., M.B., F.G.S., Professor of Hygiène and Public Health in University College. 10 Bolton-row, Mayfair, London, W.
Cormack, John Rose, M.D., F.R.S.E.
Cory, Rev. Robert, B.D., F.C.P.S. Stanground, Peterborough.
Cottam, George. 2 Winsley-street, London, W.
1857. ‡Cottam, Samuel. Brazennose-street, Manchester.

Year of Election.

1855. ‡Cotterill, Rev. Henry, Bishop of Edinburgh. Edinburgh.
1874. *Cotterill, J. H., M.A., Professor of Applied Mechanics. Royal Naval College, Greenwich, S.E.
1864. §COTTON, General FREDERICK C. Athenæum Club, Pall Mall, London, S.W.
1869. ‡COTTON, WILLIAM. Pennsylvania, Exeter.
*Cotton, Rev. William Charles, M.A. Vicarage, Frodsham, Cheshire.
1874. §Courtald, John. Bocking Bridge, Essex.
1865. ‡Courtald, Samuel, F.R.A.S. 76 Lancaster-gate, London, W.; and Gosfield Hall, Essex.
1834. ‡Cowan, Charles. 38 West Register-street, Edinburgh.
Cowan, John. Valleyfield, Pennycuick, Edinburgh.
1863. ‡Cowan, John A. Blaydon Burn, Durham.
1863. ‡Cowan, Joseph, jun. Blaydon, Durham.
1872. *Cowan, Thomas William. Hawthorn House, Horsham.
1873. *Cowans, John. Cranford, Middlesex.
Cowie, Rev. Benjamin Morgan, M.A. 42 Upper Harley-street, Cavendish-square, London, W.
1871. ‡Cowper, C. E. 3 Great George-street, Westminster, S.W.
1860. ‡Cowper, Edward Alfred, M.I.C.E. 6 Great George-street, Westminster, S.W.
1867. *Cox, Edward. Clement Park, Dundee.
1867. *Cox, George Addison. Beechwood, Dundee.
1867. ‡Cox, James. Clement Park, Lochee, Dundee.
1870. *Cox, James. 8 Falkner-square, Liverpool.
Cox, Robert. 25 Rutland-street, Edinburgh.
1867. *Cox, Thomas Hunter. Duncarse, Dundee.
1867. ‡Cox, William. Foggley, Lochee, by Dundee.
1866. *Cox, William H. 50 Newhall-street, Birmingham.
1871. ‡Cox, William J. 2 Vanburgh-place, Leith.
Craig, J. T. Gibson, F.R.S.E. 24 York-place, Edinburgh.
1859. ‡Craig, S. The Wallands, Lewes, Sussex.
1857. ‡Crampton, Rev. Josiah., M.R.I.A. The Rectory, Florence-court, Co. Fermanagh, Ireland.
1858. ‡Cranage, Edward, Ph.D. The Old Hall, Wellington, Shropshire.
1871. *Crawford, William Caldwell. Eagle Foundry, Port Dundas, Glasgow.
1871. ‡Crawshaw, Edward. Burnley, Lancashire.
1870. *Crawshay, Mrs. Robert. Cyfarthfa Castle, Merthyr Tydvil.
Creyke, The Venerable Archdeacon. Bolton Percy Rectory, Tadcaster.
1865. ‡Crocker, Edwin, F.C.S. 76 Hungerford-road, Holloway, London, N.
1858. ‡Crofts, John. Hillary-place, Leeds.
1859. ‡Croll, A. A. 10 Coleman-street, London, E.C.
1857. ‡Crolly, Rev. George. Maynooth College, Ireland.
1855. ‡*Crompton, Charles, M.A.*
*CROMPTON, Rev. JOSEPH, M.A. Bracondale, Norwich.
1866. ‡Cronin, William. 4 Brunel-terrace, Nottingham.
1870. §Crookes, Joseph. Marlborough House, Brook Green, Hammersmith, London, W.
1865. §CROOKES, WILLIAM, F.R.S., F.C.S. 20 Mornington-road, Regent's Park, London, N.W.
1855. ‡Cropper, Rev. John. Wareham, Dorsetshire.
1870. ‡Crosfield, C. J. 5 Alexandra-drive, Prince's Park, Liverpool.
1870. *Crosfield, William, jun. 5 Alexandra-drive, Prince's Park, Liverpool.
1870. ‡Crosfield, William, sen. Annesley, Aigburth, Liverpool.
1861. ‡Cross, Rev. John Edward, M.A. Appleby Vicarage, near Brigg.
1868. ‡Crosse, Thomas William. St. Giles's-street, Norwich.

Year of Election.

1867. §CROSSKEY, Rev. H. W., F.G.S. 28 George-street, Edgbaston, Birmingham.
1853. ‡Crosskill, William, C.E. Beverley, Yorkshire.
1870. *Crossley, Edward, F.R.A.S. Bermerside, Halifax.
1871. ‡Crossley, Herbert. Broomfield, Halifax.
1866. *Crossley, Louis J., F.M.S. Moorside Observatory, near Halifax.
1861. §Crowley, Henry. Smedley New Hall, Cheetham, Manchester.
1863. ‡Cruddas, George. Elswick Engine Works, Newcastle-on-Tyne.
1860. ‡Cruickshank, John. City of Glasgow Bank, Aberdeen.
1859. ‡Cruickshank, Provost. Macduff, Aberdeen.
1873. §Crust, Walter. Hall-street, Spalding.
Culley, Robert. Bank of Ireland, Dublin.
1859. ‡Cumming, Sir A. P. Gordon, Bart. Altyre.
1874. §Cumming, Professor. 33 Wellington-place, Belfast.
1861. *Cunliffe, Edward Thomas. The Elms, Handforth, Manchester.
1861. *Cunliffe, Peter Gibson. The Elms, Handforth, Manchester.
1852. ‡Cunningham, John. Macedon, near Belfast.
1869. ‡CUNNINGHAM, Professor ROBERT O., M.D., F.L.S. Queen's College, Belfast.
1855. ‡Cunningham, William A. Manchester and Liverpool District Bank, Manchester.
1850. ‡Cunningham, Rev. William Bruce. Prestonpans, Scotland.
1866. ‡Cunnington, John. 68 Oakley-square, Bedford New Town, London, N.W.
1867. *Cursetjee, Manockjee, F.R.S.A., Judge of Bombay. Villa-Byculla, Bombay.
1857. ‡Curtis, Professor Arthur Hill, LL.D. Queen's College, Galway.
1866. ‡*Cusins, Rev. F. L.*
1834. *Cuthbert, John Richmond. 40 Chapel-street, Liverpool.

1863. ‡Daglish, John. Hetton, Durham.
1854. ‡Daglish, Robert, C.E. Orrell Cottage, near Wigan.
1863. ‡Dale, J. B. South Shields.
1853. ‡Dale, Rev. P. Steele, M.A. Hollingfare, Warrington.
1865. ‡Dale, Rev. R. W. 12 Calthorpe-street, Birmingham.
1867. ‡Dalgleish, W Dundee.
1870. ‡*Dallinger, Rev. W. H.*
Dalmahoy, James, F.R.S.E. 9 Forres-street, Edinburgh.
1859. ‡Dalrymple, Charles Elphinstone. West Hall, Aberdeenshire.
1859. ‡Dalrymple, Colonel. Troup, Scotland.
Dalton, Edward, LL.D., F.S.A. Dunkirk House, Nailsworth.
Dalziel, John, M.D. Holm of Drumlanrig, Thornhill, Dumfriesshire.
1862. ‡Danby, T. W. Downing College, Cambridge.
1859. ‡Dancer, J. B., F.R.A.S. Old Manor House, Ardwick, Manchester.
1873. ‡Danchill, F. H. Vale Hall, Horwich, Bolton, Lancashire.
1849. **Danson, Joseph, F.C.S.*
1859. ‡Darbishire, Charles James. Rivington, near Chorley, Lancashire.
1861. *DARBISHIRE, ROBERT DUKINFIELD, B.A., F.G.S. 26 George-street, Manchester.
DARWIN, CHARLES R., M.A., F.R.S., F.L.S., F.G.S., Hon. F.R.S.E., and M.R.I.A. Down, near Bromley, Kent.
1848. ‡DaSilva, Johnson. Burntwood, Wandsworth Common, London, S.W.
1872. §Davenport, John T. 64 Marine Parade, Brighton.
Davey, Richard, F.G.S. Redruth, Cornwall.
1870. ‡Davidson, Alexander, M.D. 8 Peel-street, Toxteth Park, Liverpool.
1859. ‡Davidson, Charles. Grove House, Auchmull, Aberdeen.
1871. §Davidson, James. Newbattle, Dalkeith, N.B.

Year of Election.

1859. ‡Davidson, Patrick. Inchmarlo, near Aberdeen.
1872. ‡DAVIDSON, THOMAS, F.R.S., F.G.S. 8 Denmark-terrace, Brighton.
1868. ‡*Davie, Rev. W. C.*
1870. ‡Davies, Edward, F.C.S. Royal Institution, Liverpool.
1863. ‡Davies, Griffith. 17 Cloudesley-street, Islington, London, N.
Davies, John Birt, M.D. The Laurels, Edgbaston, Birmingham.
1842. Davies-Colley, Dr. Thomas. 40 Whitefriars, Chester.
1873. *Davis, Alfred. Sun Foundry, Leeds.
1870. *Davis, A. S. 37 Montpellier-villas, Cheltenham.
1864. ‡DAVIS, CHARLES E., F.S.A. 55 Pulteney-street, Bath.
Davis, Rev. David, B.A. Lancaster.
1873. *Davis, James W. Albert House, Greetland, near Halifax.
1856. *DAVIS, Sir JOHN FRANCIS, Bart., K.C.B., F.R.S., F.R.G.S. Hollywood, Westbury by Bristol.
1859. ‡DAVIS, J. BARNARD, M.D., F.R.S., F.S.A. Shelton, Hanley, Staffordshire.
1859. *Davis, Richard, F.L.S. 9 St. Helen's-place, London, E.C.
1873. ‡Davis, William Samuel. 1 Cambridge-villas, Derby.
1864. ‡Davison, Richard. Beverley-road, Great Driffield, Yorkshire.
1857. ‡Davy, Edmund W., M.D. Kimmage Lodge, Roundtown, near Dublin.
1869. ‡Daw, John. Mount Radford, Exeter.
1869. ‡Daw, R. M. Bedford-circus, Exeter.
1854. *Dawbarn, William. Elmswood, Aigburth, Liverpool.
Dawes, John Samuel, F.G.S. Lappel Lodge, Quinton, near Birmingham.
1860. *Dawes, John T., jun. Perry Hill House, Quinton, near Birmingham.
1864. ‡DAWKINS, W. BOYD, M.A., F.R.S., F.G.S., F.S.A. Birchview, Norman-road, Rusholme, Manchester.
1865. ‡Dawson, George, M.A. Shenstone, Lichfield.
*Dawson, Henry. Shu-le-Crow House, Keswick, Cumberland.
Dawson, John. Barley House, Exeter.
1855. ‡DAWSON, JOHN W., M.A., LL.D., F.R.S., Principal of M'Gill College, Montreal, Canada.
1859. *Dawson, Captain William G. Plumstead Common-road, Kent, S.E.
1871. ‡Day, St. John Vincent. 166 Buchanan-street, Glasgow.
1870. §Deacon, G. F., M.I.C.E. Liverpool.
1861. ‡Deacon, Henry. Appleton House, near Warrington.
1870. ‡*Deacon, Henry Wade.*
1859. ‡Dean, David. Banchory, Aberdeen.
1861. ‡Dean, Henry. Colne, Lancashire.
1870. *Deane, Rev. George, D.Sc., B.A., F.G.S. Moseley, Birmingham.
1854. ‡DEANE, HENRY, F.L.S. Clapham Common, London, S.W.
1866. ‡DEBUS, HEINRICH, Ph.D., F.R.S., F.C.S. Lecturer on Chemistry at Guy's Hospital, London, S.E.
1854. *DE LA RUE, WARREN, D.C.L., Ph.D., F.R.S., F.C.S., F.R.A.S. 73 Portland-place, London, W.
1870. ‡De Meschin, Thomas, M.A., LL.D. 3 Middle Temple-lane, Temple, London, E.C.
Denchar, John. Morningside, Edinburgh.
Dent, William Yerbury. Royal Arsenal, Woolwich, S.E.
1870. *Denton, J. Bailey. 22 Whitehall-place, London, S.W.
1874. §De Rance, C.E., F.G.S. 28 Jermyn-street, London, S.W.
1856. *DERBY, The Right Hon. the Earl of, LL.D., F.R.S., F.R.G.S. 23 St. James's-square, London, S.W.; and Knowsley, near Liverpool.

Year of Election.

1874. §Derham, W. Henley House, Westbury-on-Trym, Bristol.
De Saumarez, Rev. Havilland, M.A. St. Peter's Rectory, Northampton.
1870. ‡Desmond, Dr. 44 Irvine-street, Edge Hill, Liverpool.
1868. ‡Dessé, Etheldred, M.B., F.R.C.S. 43 Kensington Gardens-square, Bayswater, London, W.
De Tabley, George, Lord, F.Z.S. Tabley House, Knutsford, Cheshire.
1869. ‡Devon, The Right Hon. the Earl of, D.C.L. Powderham Castle, near Exeter.
*Devonshire, William, Duke of, K.G., M.A., LL.D., F.R.S., F.G.S., F.R.G.S., Chancellor of the University of Cambridge. Devonshire House, Piccadilly, London, W.; and Chatsworth, Derbyshire.
1868. §Dewar, James, F.R.S.E. Chemical Laboratory, The University, Edinburgh.
1872. ‡Dewick, Rev. E. S. The College, Eastbourne, Sussex.
1873. *Dew-Smith, A. G. Rushett House, Thames Ditton.
1858. ‡Dibb, Thomas Townend. Little Woodhouse, Leeds.
1870. ‡*Dickens, Colonel C. H.*
1852. ‡Dickie, George, M.A., M.D., F.L.S., Professor of Botany in the University of Aberdeen.
1864. *Dickinson, F. H., F.G.S. Kingweston, Somerton, Taunton; and 121 St. George's-square, London, S.W.
1863. ‡Dickinson, G. T. Claremont-place, Newcastle-on-Tyne.
1861. *Dickinson, William Leeson 1 St. James's-street, Manchester.
1867. §Dickson, Alexander, M.D., Professor of Botany in the University of Glasgow. 11 Royal-circus, Edinburgh.
1868. ‡Dickson, J. Thompson. 33 Harley-street, London, W.
1863. *Dickson, William, F.S.A., Clerk of the Peace for Northumberland. Alnwick, Northumberland.
1862. *Dilke, Sir Charles Wentworth, Bart., M.P., F.R.G.S. 76 Sloane-street, London, S.W.
1848. ‡Dillwyn, Lewis Llewelyn, M.P., F.L.S., F.G.S. Parkwern, near Swansea.
1872. §Dines, George. Grosvenor-road, London, S.W.
1869. ‡Dingle, Edward. 19 King-street, Tavistock.
1859. *Dingle, Rev. J. Lanchester Vicarage, Durham.
1837. Dircks, Henry, C.E., LL.D., F.C.S. 48 Charing-cross, London, S.W.
1868. ‡*Dittmar, W.*
1874. *Dixon, A. E. Dunowen, Cliftonville, Belfast.
1853. ‡Dixon, Edward, M.I.C.E. Wilton House, Southampton.
1865. ‡*Dixon, L.*
1861. ‡Dixon, W. Hepworth, F.S.A., F.R.G.S. 6 St. James's-terrace, Regent's-park, London, N.W.
*Dobbin, Leonard, M.R.I.A. 27 Gardiner's-place, Dublin.
1851. ‡Dobbin, Orlando T., LL.D., M.R.I.A. Ballivor, Kells, Co. Meath.
1860. *Dobbs, Archibald Edward, M.A. Richmond-road, Ealing, W.
1864. *Dobson, William. Oakwood, Bathwick Hill, Bath.
Dockray, Benjamin.
1870. *Dodd, John. 6 Thomas-street, Liverpool.
1874. §Dodd, W. H., M.A., Barrington Lecturer on Political Economy. Mountjoy-street, Dublin.
1857. ‡Dodds, Thomas W., C.E. Rotherham.
*Dodsworth, Benjamin. Westwood, Scarborough.
*Dodsworth, George. The Mount, York.
Dolphin, John. Delves House, Berry Edge, near Gateshead.

Year of Election.

1851. ‡Domvile, William C., F.Z.S. Thorn Hill, Bray, Dublin.
1867. ‡Don, John. The Lodge, Broughty Ferry, by Dundee.
1867. ‡Don, William G. St. Margaret's, Broughty Ferry, by Dundee.
1873. ‡Donham, Thomas. Huddersfield.
1869. ‡Donisthorpe, G. T. St. David's Hill, Exeter.
1871. ‡Donkin, Arthur Scott, M.D., Lecturer on Forensic Medicine at Durham University. Sunderland.
1874. §Donnell, Professor, M.A. 28 Upper Sackville-street, Dublin.
1861. ‡Donnelly, Captain, R.E. South Kensington Museum, London, W.
1857. *Donnelly, William, C.B., Registrar-General for Ireland. Charlemont House, Dublin.
1857. ‡Donovan, M., M.R.I.A. Clare-street, Dublin.
1867. ‡Dougall, Andrew Maitland, R.N. Scotscraig, Tayport, Fifeshire.
1871. ‡Dougall, John, M.D. 2 Cecil-place, Paisley-road, Glasgow.
1863. **Doughty, C. Montagu.*
1855. ‡Dove, Hector. Rose Cottage, Trinity, near Edinburgh.
1870. ‡Dowie, J. M. Walstones, West Kirby, Liverpool.
Downall, Rev. John. Okehampton, Devon.
1857. ‡Downing, S., LL.D., Professor of Civil Engineering in the University of Dublin. Dublin.
1872. *Dowson, Edward, M.D. 117 Park-street, London, W.
1865. *Dowson, E. Theodore. Geldeston, near Beccles, Suffolk.
1868. §Dresser, Henry E., F.Z.S. 6 Tenterden-street, Hanover-square, London, W.
1873. §Drew, Frederick, LL.D., F.G.S. Claremont-road, Surbiton.
1869. §Drew, Joseph, LL.D., F.G.S., F.R.S.C., F.R.S.L. Weymouth.
1865. ‡Drew, Robert A. 6 Stanley-place, Duke-street, Broughton, Manchester.
1872. *Druce, Frederick. 27 Oriental-place, Brighton.
1874. §Druitt, Charles. Hampden-terrace, Rugby-road, Belfast.
Drummond, H. Home, F.R.S.E. Blair Drummond, Stirling.
1859. ‡Drummond, Robert. 17 Stratton-street, London, W.
1866. *Dry, Thomas. 23 Gloucester-road, Regent's Park, London, N.W.
1863. ‡Dryden, James. South Benwell, Northumberland.
1870. §Drysdale, J. J., M.D. 36a Rodney-street, Liverpool.
1856. *Ducie, Henry John Reynolds Moreton, Earl of, F.R.S., F.G.S. 16 Portman-square, London, W.; and Tortworth Court, Wotton-under-Edge.
1870. ‡Duckworth, Henry, F.L.S., F.G.S. 5 Cook-street, Liverpool.
1867. *Duff, Mountstuart Ephinstone Grant-, LL.B., M.P. 4 Queen's Gate-gardens, South Kensington, London, W.; and Eden, near Banff, Scotland.
1852. ‡Dufferin, The Right Hon. Lord. Highgate, London, N.; and Clandeboye, Belfast.
1859. *Duncan, Alexander. 7 Prince's-gate, London, S.W.
1859. ‡Duncan, Charles. 52 Union-place, Aberdeen.
1866. *Duncan, James. 71 Cromwell-road, South Kensington, London, W.
Duncan, J. F., M.D. 8 Upper Merrion-street, Dublin.
1871. ‡Duncan, James Matthew, M.D. 30 Charlotte-square, Edinburgh.
1867. ‡Duncan, Peter Martin, M.D., F.R.S., F.G.S., Professor of Geology in King's College, London. 40 Blessington-road, Lee, S.E.
Dunlop, Alexander. Clober, Milngavie, near Glasgow.
1853. *Dunlop, William Henry. Annanhill, Kilmarnock, Ayrshire.
1865. §Dunn, David. Annet House, Skelmorlie, by Greenock, N.B.
1862. §Dunn, Robert, F.R.C.S. 31 Norfolk-street, Strand, London, W.C.
Dunnington-Jefferson, Rev. Joseph, M.A., F.C.P.S. Thicket Hall, York.

Year of Election.

1859. ‡Duns, Rev. John, D.D., F.R.S.E. New College, Edinburgh.
1866. ‡Duprey, Perry. Woodbury Down, Stoke Newington, London, N.
1869. ‡D'Urban, W. S. M., F.L.S. 4 Queen-terrace, Mount Radford, Exeter.
1860. ‡DURHAM, ARTHUR EDWARD, F.R.C.S., F.L.S., Demonstrator of Anatomy, Guy's Hospital. 82 Brook-street, Grosvenor-square, London, W.
Dykes, Robert. Kilmorie, Torquay, Devon.
1869. §Dymond, Edward E. Oaklands, Aspley Guise, Woburn.

1868. ‡Eade, Peter, M.D. Upper St. Giles's-street, Norwich.
1861. ‡Eadson, Richard. 13 Hyde-road, Manchester.
1864. ‡*Earle, Rev. A.*
*EARNSHAW, Rev. SAMUEL, M.A. 14 Broomfield, Sheffield.
1874. §Eason, Charles. 30 Kenilworth-square, Rathgar, Dublin.
1871. *Easton, Edward. 7 Delahay-street, Westminster, S.W.
1863. §Easton, James. Nest House, near Gateshead, Durham.
Eaton, Rev. George, M.A. The Pole, Northwich.
1870. §Eaton, Richard. Basford, Nottingham.
Ebden, Rev. James Collett, M.A., F.R.A.S. Great Stukeley Vicarage, Huntingdonshire.
1867. ‡*Eckersley, James.*
1861. ‡Ecroyd, William Farrer. Spring Cottage, near Burnley.
1858. *Eddison, Francis. Blandford, Dorset.
1870. *Eddison, Dr. John Edwin. 29 Park-square, Leeds.
*Eddy, James Ray, F.G.S. Carleton Grange, Skipton.
Eden, Thomas. Talbot-road, Oxton.
*EDGEWORTH, MICHAEL P., F.L.S., F.R.A.S. Mastrim House, Anerley, London, S.E.
1855. ‡Edmiston, Robert. Elmbank-crescent, Glasgow.
1859. ‡Edmond, James. Cardens Haugh, Aberdeen.
1870. *Edmonds, F. B. 8 York-place, Northam, Southampton.
1867. *Edward, Allan. Farington Hall, Dundee.
1867. §Edward, Charles. Chambers, 8 Bank-street, Dundee.
1867. ‡Edward, James. Balruddery, Dundee.
Edwards, John.
1855. *EDWARDS, Professor J. BAKER, Ph.D., D.C.L. Montreal, Canada.
1867. ‡Edwards, William. 70 Princes-street, Dundee.
*EGERTON, Sir PHILIP DE MALPAS GREY, Bart., M.P., F.R.S., F.G.S. Oulton Park, Tarporley, Cheshire.
1859. *Eisdale, David A., M.A. 38 Dublin-street, Edinburgh.
1873. §Elcock, Charles. 71 Market-street, Manchester.
1855. ‡*Elder, David.*
1858. ‡Elder, John. Elm Park, Govan-road, Glasgow.
1868. ‡Elger, Thomas Gwyn Empy, F.R.A.S. St. Mary, Bedford.
Ellacombe, Rev. H. T., F.S.A. Clyst, St. George, Topsham, Devon.
1863. ‡Ellenberger, J. L. Worksop.
1855. §Elliot, Robert, F.B.S.E. Wolfelee, Hawick, N.B.
1861. *ELLIOT, Sir WALTER, K.C.S.I., F.L.S. Wolfelee, Hawick, N.B.
1864. ‡Elliott, E. B. Washington, United States.
1872. ‡Elliott, Rev. E. B. 11 Sussex-square, Kemp Town, Brighton.
Elliott, John Fogg. Elvet Hill, Durham.
1864. *ELLIS, ALEXANDER JOHN, B.A., F.R.S., F.S.A. 25 Argyll-road, Kensington, London, W.
1859. ‡ELLIS, HENRY S., F.R.A.S. Fair Park, Exeter.
1864. *Ellis, Joseph. Hampton Lodge, Brighton.
1864. ‡Ellis, J. Walter. High House, Thornwaite, Ripley, Yorkshire.

Year of Election.

*Ellis, Rev. Robert, A.M. The Institute, St. Saviour's Gate, York.
1874. §Ellis, Sydney. The Newarke, Leicester.
1869. ‡Ellis, William Horton. Pennsylvania, Exeter.
Ellman, Rev. E. B. Berwick Rectory, near Lewes, Sussex.
1862. ‡Elphinstone, H. W., M.A., F.L.S. Cadogan-place, London, S.W.
Eltoft, William.
1863. ‡Embleton, Dennis, M.D. Northumberland-street, Newcastle-on-Tyne.
1863. ‡Emery, Rev. W., B.D. Corpus Christi College, Cambridge.
1858. ‡Empson, Christopher. Bramhope Hall, Leeds.
1866. ‡Enfield, Richard. Low Pavement, Nottingham.
1866. ‡Enfield, William. Low Pavement, Nottingham.
1871. ‡Engelson, T. 11 Portland-terrace, Regent's Park, London, N.W.
1853. ‡English, Edgar Wilkins. Yorkshire Banking Company, Lowgate, Hull.
1869. ‡English, J. T. Stratton, Cornwall.
Enniskillen, William Willoughby, Earl of, D.C.L., F.R.S., M.R.I.A., F.G.S. 26 Eaton-place, London, S.W.; and Florence Court, Fermanagh, Ireland.
1869. ‡Ensor, Thomas. St. Leonards, Exeter.
1869. *Enys, John Davis. Canterbury, New Zealand. (Care of F. G. Enys, Esq., Enys, Penryn, Cornwall.)
1844. ‡Erichsen, John Eric, Professor of Clinical Surgery in University College, London. 9 Cavendish-place, London, W.
1864. *Eskrigge, R. A., F.G.S. 18 Hackins-hey, Liverpool.
1862. *Esson, William, M.A., F.R.S., F.C.S., F.R.A.S. Merton College; and 1 Bradmore-road, Oxford.
Estcourt, Rev. W. J. B. Long Newton, Tetbury.
1869. ‡Etheridge, Robert, F.R.S.L. & E., F.G.S., Palæontologist to the Geological Survey of Great Britain. Museum of Practical Geology, Jermyn-street; and 19 Halsey-street, Cadogan-place, London, S.W.
1855. *Euing, William. 209 West George-street, Glasgow.
1870. *Evans, Arthur John. Nash Mills, Hemel Hempstead.
1865. *Evans, Rev. Charles, M.A. The Rectory, Solihull, Birmingham.
1872. *Evans, Frederick J., C.E. Clayponds, Brentford, Middlesex, W.
1869. *Evans, H. Saville W. Wimbledon Park House, Wimbledon, S.W.
1861. *Evans, John, F.R.S., F.S.A., Pres. G.S. 65 Old Bailey, London, E.C.; and Nash Mills, Hemel Hempstead.
1865. ‡Evans, Sebastian, M.A., LL.D. Highgate, near Birmingham.
1866. ‡Evans, Thomas, F.G.S. Belper, Derbyshire.
1865. *Evans, William. Ellerslie, Augustus-road, Edgbaston, Birmingham.
1871. §Eve, H. W. Wellington College, Wokingham, Berkshire.
1868. *Everett, J. D., D.C.L., F.R.S.E., Professor of Natural Philosophy in Queen's College, Belfast. Rushmere, Malone-road, Belfast.
1863. *Everitt, George Allen, K.L., K.H., F.R.G.S. Knowle Hall, Warwickshire.
1874. §Ewart, William. Glenmachan, Belfast.
1874. §Ewart, W. Quartus. Glenmachan, Belfast.
1859. *Ewing, Archibald Orr, M.P. Ballikinrain Castle, Killearn, Stirlingshire.
1871. *Exley, John T., M.A. 1 Cotham-road, Bristol.
1846. *Eyre, George Edward, F.G.S., F.R.G.S. 59 Lowndes-square, London, S.W.; and Warren's, near Lyndhurst, Hants.
1866. ‡Eyre, Major-General Sir Vincent, F.R.G.S. Athenæum Club, Pall Mall, London, S.W.

Year of Election.

Eyton, Charles. Hendred House, Abingdon.
1849. ‡Eyton, T. C. Eyton, near Wellington, Salop.

1842. Fairbairn, Thomas. Manchester.
1865. ‡Fairley, Thomas. Chapel Allerton, Leeds.
1870. ‡Fairlie, Robert, C.E. Woodlands, Clapham Common, London, S.W.
1864. ‡Falkner, F. H. Lyncombe, Bath.
1873. §Farakerley, Miss. The Castle, Denbigh.
1859. ‡Farquharson, Robert O. Houghton, Aberdeen.
1861. §FARR, WILLIAM, M.D., D.C.L., F.R.S., Superintendent of the Statistical Department, General Registry Office. Southlands, Bickley, Kent.
1866. *FARRAR, Rev. FREDERICK WILLIAM, M.A., D.D., F.R.S. Marlborough College, Wilts.
1857. ‡Farrelly, Rev. Thomas. Royal College, Maynooth.
1869. *Faulconer, R. S. Fairlawn, Clarence-road, Clapham Park, London, S.W.
1869. *Faulding, Joseph. The Grange, Greenhill Park, New Barnet, Herts.
1869. ‡Faulding, W. F. Didsbury College, Manchester.
1859. *FAWCETT, HENRY, M.P., Professor of Political Economy in the University of Cambridge. 51 The Lawn, South Lambeth-road, London, S.W.; and 8 Trumpington-street, Cambridge.
1863. ‡Fawcus, George. Alma-place, North Shields.
1845. ‡Felkin, William, F.L.S. The Park, Nottingham.
Fell, John B. Spark's Bridge, Ulverston, Lancashire.
1864. §FELLOWS, FRANK P., F.S.A., F.S.S. 8 The Green, Hampstead, London, N.W.
1852. ‡Fenton, S. Greame. 9 College-square; and Keswick, near Belfast.
1855. ‡Ferguson, James. Gas Coal Works, Lesmahago, Glasgow.
1859. ‡Ferguson, John. Cove, Nigg, Inverness.
1871. §Ferguson, John. The College, Glasgow.
1867. ‡Ferguson, Robert M., Ph.D., F.R.S.E. 8 Queen-street, Edinburgh.
1857. ‡Ferguson, Samuel. 20 North Great George-street, Dublin.
1854. ‡Ferguson, William, F.L.S., F.G.S. Kinmundy, near Mintlaw, Aberdeenshire.
1867. *Fergusson, H. B. 13 Airlie-place, Dundee.
1863. *FERNIE, JOHN. Bonchurch, Isle of Wight.
1862. ‡FERRERS, Rev. N. M., M.A. Caius College, Cambridge.
1873. ‡Ferrier, David, M.D. 23 Somerset-street, Portman-square, London, W.
1868. ‡Field, Edward. Norwich.
1869. *FIELD, ROGERS. 5 Cannon-row, Westminster, S.W.
Fielding, G. H., M.D.
1864. ‡Finch, Frederick George, B.A., F.G.S. 21 Crooms-hill, Greenwich, S.E.
Finch, John. Bridge Work, Chepstow.
Finch, John, jun. Bridge Work, Chepstow.
1863. ‡*Finney, Samuel.*
1868. ‡Firth, G. W. W. St. Giles's-street, Norwich.
Firth, Thomas. Northwick.
1863. *Firth, William. Burley Wood, near Leeds.
1851. *FISCHER, WILLIAM L. F., M.A., LL.D., F.R.S., Professor of Mathematics in the University of St. Andrews. St. Andrews, Scotland.
1858. ‡Fishbourne, Captain E. G., R.N. 6 Welamere-terrace, Paddington, London, W.

Year of Election.

1869. ‡FISHER, Rev. OSMOND, M.A., F.G.S. Harlston Rectory, near Cambridge.
1873. §Fisher, William. Maes Fron, near Welshpool, Montgomeryshire.
1858. ‡Fishwick, Henry. Carr-hill, Rochdale.
1871. *Fison, Frederick W., F.C.S. Crossbeck, Ilkley, Yorkshire.
1871. §FITCH, J. G., M.A. 5 Lancaster-terrace, Regent's Park, London, N.W.
1868. ‡Fitch, Robert, F.G.S., F.S.A. Norwich.
1857. ‡Fitzgerald, The Right Hon. Lord Otho. 13 Dominick-street, Dublin.
1857. ‡Fitzpatrick, Thomas, M.D. 31 Lower Bagot-street, Dublin.
Fitzwilliam, Hon. George Wentworth, F.R.G.S. 19 Grosvenor-square, London, S.W.; and Wentworth House, Rotherham.
1865. ‡Fleetwood, D. J. 45 George-street, St. Paul's, Birmingham.
Fleetwood, Sir Peter Hesketh, Bart. Rossall Hall, Fleetwood, Lancashire.
1850. ‡Fleming, Professor Alexander, M.D. 121 Hagley-road, Birmingham.
Fleming, Christopher, M.D. Merrion-square North, Dublin.
Fleming, John G., M.D. 155 Bath-street, Glasgow.
*FLEMING, WILLIAM, M.D. Rowton Grange, near Chester.
1867. §FLETCHER, ALFRED E. 21 Overton-street, Liverpool.
1870. ‡Fletcher, B. Edgington. Norwich.
1853. ‡FLETCHER, ISAAC, F.R.S., F.G.S., F.R.A.S. Tarn Bank, Workington.
1869. §FLETCHER, LAVINGTON E., C.E. 41 Corporation-street, Manchester.
Fletcher, T. B. E., M.D. 7 Waterloo-street, Birmingham.
1862. ‡FLOWER, WILLIAM HENRY, F.R.S., F.L.S., F.G.S., F.R.C.S., Hunterian Professor of Comparative Anatomy, and Conservator of the Museum of the Royal College of Surgeons. Royal College of Surgeons, Lincoln's-Inn-fields, London, W.C.
1867. ‡Foggie, William. Woodville, Maryfield, Dundee.
1854. *FORBES, DAVID, F.R.S., F.G.S., F.C.S. 11 York-place, Portman-square, London, W.
1873. *Forbes, Professor George, B.A., F.R.S.E. Anderson's University, Glasgow.
1855. ‡Forbes, Rev. John. Symington Manse, Biggar, Scotland.
1855. ‡Forbes, Rev. John, D.D. 150 West Regent-street, Glasgow.
Ford, H. R. Morecombe Lodge, Yealand Conyers, Lancashire.
1866. ‡Ford, William. Hartsdown Villa, Kensington Park-gardens East, London, W.
*Forrest, William Hutton. The Terrace, Stirling.
1867. ‡Forster, Anthony. Finlay House, St. Leonard's-on-Sea.
1858. *FORSTER, The Right Hon. WILLIAM EDWARD, M.P. Wharfeside, Burley-in-Wharfedale, Leeds.
1871. ‡*Forsyth, William F.*
1854. *Fort, Richard. 24 Queen's-gate-gardens, London, W.; and Read Hall, Whalley, Lancashire.
1870. ‡Forwood, William B. Hopeton House, Seaforth, Liverpool.
1865. ‡Foster, Balthazar W., M.D. 4 Old-square, Birmingham.
1865. *FOSTER, CLEMENT LE NEVE, B.A., D.Sc., F.G.S. Truro, Cornwall.
1857. *FOSTER, GEORGE C., B.A., F.R.S., F.C.S., Professor of Experimental Physics in University College, London, W.C. 12 Hilldrop-road, London, N.
*Foster, Rev. John, M.A. The Oaks Vicarage, Loughborough.
1845. ‡Foster, John N. Sandy Place, Sandy, Bedfordshire.
1859. *FOSTER, MICHAEL, M.A., M.D., F.R.S., F.L.S., F.C.S. (GENERAL SECRETARY.) Trinity College, and Great Shelford, near Cambridge.

Year of Election.

1859. §FOSTER, PETER LE NEVE, M.A. Society of Arts, Adelphi, London, W.C.
1873. ‡Foster, Peter Le Neve, jun. Mortara, Italy.
1863. ‡Foster, Robert. 30 Rye-hill, Newcastle-upon-Tyne.
1859. *Foster, S. Lloyd. Old Park Hall, Walsall, Staffordshire.
1873. *Foster, William. Harrowins House, Queensbury, Yorkshire.
1842. Fothergill, Benjamin. 10 The Grove, Boltons, West Brompton, London, S.W.
1870. ‡Foulger, Edward. 55 Kirkdale-road, Liverpool.
1866. §Fowler, George. Basford Hall, near Nottingham.
1868. ‡Fowler, G. G. Gunton Hall, Lowestoft, Suffolk.
1856. ‡Fowler, Rev. Hugh, M.A. College-gardens, Gloucester.
1870. *Fowler, Robert Nicholas, M.A., F.R.G.S. 50 Cornhill, London, E.C.
1868. ‡Fox, Colonel A. H. LANE, F.G.S., F.S.A. 10 Upper Phillimore-gardens, Kensington, London, S.W.
1842. *Fox, Charles. Trebah, Falmouth.
*Fox, Rev. Edward, M.A. The Vicarage, Romford, Essex.
*Fox, Joseph Hayland. The Cleve, Wellington, Somerset.
1860. ‡Fox, Joseph John. Church-row, Stoke Newington, London, N.
Fox, ROBERT WERE, F.R.S. Falmouth.
1866. *Francis, G. B. 43 Stoke Newington-green, London, N.
FRANCIS, WILLIAM, Ph.D., F.L.S., F.G.S., F.R.A.S. Red Lion-court, Fleet-street, London, E.C.; and Manor House, Richmond, Surrey.
1846. ‡FRANKLAND, EDWARD, D.C.L., Ph.D., F.R.S., F.C.S., Professor of Chemistry in the Royal School of Mines. 14 Lancaster-gate, London, W.
*Frankland, Rev. Marmaduke Charles. Chowbent, near Manchester.
1859. ‡Fraser, George B. 3 Airlie-place, Dundee.
Fraser, James. 25 Westland-row, Dublin.
Fraser, James William. 8A Kensington Palace-gardens, London, W.
1865. *FRASER, JOHN, M.A., M.D. Chapel Ash, Wolverhampton.
1871. ‡FRASER, THOMAS R., M.D., F.R.S.E. 3 Grosvenor-street, Edinburgh.
1859. *Frazer, Daniel. 113 Buchanan-street, Glasgow.
1871. ‡Frazer, Evan L. R. Brunswick-terrace, Spring Bank, Hull.
1860. ‡Freeborn, Richard Fernandez. 38 Broad-street, Oxford.
1847. *Freeland, Humphrey William, F.G.S. West-street, Chichester, Sussex.
1871. ‡*Freeman.*
1865. ‡Freeman, James. 15 Francis-road, Edgbaston, Birmingham.
Frere, George Edward, F.R.S. Roydon Hall, Diss, Norfolk.
1869. ‡FRERE, The Right Hon. Sir H. BARTLE E., G.C.S.I., K.C.B., F.R.G.S. Wressil Lodge, Wimbledon, S.W.
1869. ‡Frere, Rev. William Edward. The Rectory, Bilton, near Bristol.
Fripp, George, D., M.D.
1857. *Frith, Richard Hastings, C.E., M.R.I.A., F.R.G.S.I. 48 Summer-hill, Dublin.
1869. ‡Frodsham, Charles. 26 Upper Bedford-place, Russell-square, London, W.C.
1847. ‡Frost, William. Wentworth Lodge, Upper Tulse-hill, London, S.W.
1860. *FROUDE, WILLIAM, C.E., F.R.S. Chelston Cross, Torquay.
Fry, Francis. Cotham, Bristol.
Fry, Richard. Cotham Lawn, Bristol.
Fry, Robert. Tockington, Gloucestershire.

Year of Election.

1872. *Fuller, Rev. A. Ichenor, Chichester.
1873. §Fuller, Claude S., R.N. 44 Holland-road, Kensington, W.
1859. ‡Fuller, Frederick, M.A., Professor of Mathematics in University and King's College, Aberdeen.
1869. ‡Fuller, George, C.E., Professor of Engineering in Queen's College, Belfast. 6 College-gardens, Belfast.
1864. *Furneaux, Rev. Alan. St. German's Parsonage, Cornwall.

*Gadesden, Augustus William, F.S.A. Ewell Castle, Surrey.
1857. ‡Gages, Alphonse, M.R.I.A. Museum of Irish Industry, Dublin.
1863. *Gainsford, W. D. Richmond Hill, Sheffield.
1850. ‡Gairdner, Professor W. F., M.D. 225 St. Vincent-street, Glasgow.
1861. ‡Galbraith, Andrew. Glasgow.
Galbraith, Rev. J. A., M.R.I.A. Trinity College, Dublin.
1867. ‡Gale, James M. 33 Miller-street, Glasgow.
1863. ‡Gale, Samuel, F.C.S. 338 Oxford-street, London, W.
1861. ‡Galloway, Charles John. Knott Mill Iron Works, Manchester.
1861. ‡Galloway, John, jun. Knott Mill Iron Works, Manchester.
1860. *Galton, Captain Douglas, C.B., R.E., F.R.S., F.L.S., F.G.S., F.R.G.S. (General Secretary.) 12 Chester-street, Grosvenor-place, London, S.W.
1860. *Galton, Francis, F.R.S., F.G.S., F.R.G.S. 42 Rutland-gate, Knightsbridge, London, S.W.
1869. ‡Galton, John C., M.A., F.L.S. 13 Margaret-street, Cavendish-square, London, W.
1870. §Gamble, Lieut.-Col. D. St. Helen's, Lancashire.
1870. *Gamble, John G. Savile Club, 15 Savile-row, London, W.
1868. ‡Gamgee, Arthur, M.D., F.R.S., F.R.S.E. Owens College, Manchester.
1862 §Garner, Robert, F.L.S. Stoke-upon-Trent.
1865. §Garner, Mrs. Robert. Stoke-upon-Trent.
1842. Garnett, Jeremiah. Warren-street, Manchester.
1873. §Garnham, John. 123 Bunhill-row, London, E.C.
1874. *Garstin, John Ribton, M.R.I.A., F.S.A. Greenhill, Killiney, Co. Dublin.
1870. ‡Gaskell, Holbrook. Woolton Wood, Liverpool.
1870. *Gaskell, Holbrook, jun. Mayfield-road, Aigburth, Liverpool.
1847. *Gaskell, Samuel. Windham Club, St. James's-square, London, S.W.
1842. Gaskell, Rev. William, M.A. Plymouth-grove, Manchester.
1846. §Gassiot, John Peter, D.C.L., LL.D., F.R.S., F.C.S. Clapham Common, London, S.W.
1862. *Gatty, Charles Henry, M.A., F.L.S., F.G.S. Felbridge Park, East Grinstead, Sussex.
1873. ‡Geach, R. G. Cragg Wood, Rawdon, Yorkshire.
1871. ‡Geddes, John. 9 Melville-crescent, Edinburgh.
1859. ‡Geddes, William D., M.A., Professor of Greek, King's College, Old Aberdeen.
1854. ‡Gee, Robert, M.D. 5 Abercromby-square, Liverpool.
1867. §Geikie, Archibald, LL.D., F.R.S., F.G.S., Director of the Geological Survey of Scotland. Geological Survey Office, Victoria-street, Edinburgh; and Ramsay Lodge, Edinburgh.
1871. §Geikie, James, F.R.S.E. 16 Duncan-terrace, Newington, Edinburgh.
1855. ‡Gemmell, Andrew. 38 Queen-street, Glasgow.
1854. §Gerard, Henry. 8a Rumford-place, Liverpool.
1870. ‡Gerstl, R. University College, London, W.C.
1870. *Gervis, Walter S., M.D. Ashburton, Devonshire.
1856. *Gething, George Barkley. Springfield, Newport, Monmouthshire.

Year of Election.

1863. *GIBB, Sir GEORGE DUNCAN, Bart., M.D., M.A., LL.D., F.G.S. 1 Bryanston-street, London, W.; and Falkland, Fife.
1865. ‡Gibbins, William. Battery Works, Digbeth, Birmingham.
1871. ‡Gibson, Alexander. 19 Albany-street, Edinburgh.
1868. ‡Gibson, C. M. Bethel-street, Norwich.
1874. §Gibson, Edward, Q.C. 23 Fitzwilliam-square, Dublin.
*Gibson, George Stacey. Saffron Walden, Essex.
1852. ‡Gibson, James. 35 Mountjoy-square, Dublin.
1870. ‡*Gibson, R. E.*
1870. ‡Gibson, Thomas. 51 Oxford-street, Liverpool.
1870. ‡Gibson, Thomas, jun. 19 Parkfield-road, Princes Park, Liverpool.
1867. ‡Gibson, W. L., M.D. Tay-street, Dundee.
1842. GILBERT, JOSEPH HENRY, Ph.D., F.R.S., F.C.S. Harpenden, near St. Albans.
1857. ‡Gilbert, J. T., M.R.I.A. Blackrock, Dublin.
1859. *Gilchrist, James, M.D. Crichton House, Dumfries.
Gilderdale, Rev. John, M.A. Walthamstow, Essex, E.
Giles, Rev. William. Netherleigh House, near Chester.
1871. *Gill, David, jun. The Observatory, Aberdeen.
1868. ‡Gill, Joseph. Palermo, Sicily. (Care of W. H. Gill, Esq., General Post Office, St. Martin's-le-Grand, E.C.)
1864. ‡GILL, THOMAS. 4 Sydney-place, Bath.
1861. *Gilroy, George. Hindley Hall, Wigan.
1867. ‡Gilroy, Robert. Craigie, by Dundee.
1867. §GINSBURG, Rev. C. D., D.C.L., LL.D. Binfield, Bracknell, Berkshire.
1869. ‡Girdlestone, Rev. Canon E., M.A. Halberton Vicarage, Tiverton.
1874. *Girdwood, James Kennedy. Old Park, Belfast.
1850. *Gladstone, George, F.C.S., F.R.G.S. 31 Ventnor-villas, Cliftonville, Brighton.
1849. *GLADSTONE, JOHN HALL, Ph.D., F.R.S., F.C.S., Fullerian Professor of Chemistry in the Royal Institution. 17 Pembridge-square, Hyde Park, London, W.
1861. *Gladstone, Murray. 36 Wilton-crescent, London, S.W.
1861. *GLAISHER, JAMES, F.R.S., F.R.A.S. 1 Dartmouth-place, Blackheath, London, S.E.
1871. *GLAISHER, J. W. L., M.A., F.R.A.S. Trinity College, Cambridge.
1853. ‡Gleadon, Thomas Ward. Moira-buildings, Hull.
1870. §Glen, David Corse. 14 Annfield-place, Glasgow.
1859. ‡Glennie, J. S. Stuart. 6 Stone-buildings, Lincoln's-Inn, London, W.C.
1867. ‡Gloag, John A. L. 10 Inverleith-place, Edinburgh.
Glover, George. Ranelagh-road, Pimlico, London, S.W.
1874. §Glover, George T. 30 Donegall-place, Belfast.
Glover, Thomas. Becley Old Hall, Rowsley, Bakewell.
1874. §Glover, Thomas. 77 Claverton-street, London, S.W.
1870. ‡Glynn, Thomas R. 1 Rodney-street, Liverpool.
1872. §GODDARD, RICHARD. 16 Booth-street, Bradford, Yorkshire.
1852. ‡Godwin, John. Wood House, Rostrevor, Belfast.
1846. ‡GODWIN-AUSTEN, ROBERT A. C., B.A., F.R.S., F.G.S. Chilworth Manor, Guildford.
GOLDSMID, Sir FRANCIS HENRY, Bart., M.P. St. John's Lodge, Regent's Park, London, N.W.
1873. §Goldthorp, Miss R. F. C. Cleckheaton, Bradford, Yorkshire.
1852. ‡Goodbody, Jonathan. Clare, King's County, Ireland.
1870. ‡Goodison, George William, C.E. Gateacre, Liverpool.
1842. *GOODMAN, JOHN, M.D. 8 Leicester-street, Southport.
1865. ‡Goodman, J. D. Minories, Birmingham.
1869. ‡Goodman, Neville. Peterhouse, Cambridge.

Year of Election.

1870. *Goodwin, Rev. Henry Albert, M.A., F.R.A.S. Westhall Vicarage, Wangford.
1871. §Gordon, Joseph. Poynter's-row, Totteridge, Whetstone, London, N.
1840. ‡Gordon, Lewis D. B. Totteridge, Whetstone, London, N.
1857. ‡Gordon, Samuel, M.D. 11 Hume-street, Dublin.
1865. ‡Gore, George, F.R.S. 50 Islington-row, Edgbaston, Birmingham.
1870. ‡Gossage, William. Winwood, Woolton, Liverpool.
*Gotch, Rev. Frederick William, LL.D. Stokes Croft, Bristol.
*Gotch, Thomas Henry. Kettering.
1873. §Gott, Charles, M.I.C.E. Parkfield-road, Manningham, Bradford.
1849. ‡Gough, The Hon. Frederick. Perry Hall, Birmingham.
1857. ‡Gough, George S., Viscount. Rathronan House, Clonmel.
1868. §Gould, Rev. George. Unthank-road, Norwich.
GOULD, JOHN, F.R.S., F.L.S., F.R.G.S., F.Z.S. 26 Charlotte-street, Bedford-square, London, W.C.
1854. ‡*Gourlay, Daniel De la C., M.D.*
1873. ‡Gourlay, J. McMillan. 21 St. Andrew's-place, Bradford, Yorkshire.
1867. ‡Gourley, Henry (Engineer). Dundee.
Gowland, James. London-wall, London, E.C.
1873. §Goyder, Dr. D. Manville-crescent, Bradford, Yorkshire.
1861. ‡Grafton, Frederick W. Park-road, Whalley Range, Manchester.
1867. *GRAHAM, CYRIL, F.L.S., F.R.G.S. 9 Cleveland-row, St. James's, London, S.W.
Graham, Lieutenant David. Mecklewood, Stirlingshire.
1852. *Grainger, Rev. John, D.D. Skerry and Rathcavan Rectory, Broughshane, near Ballymena, Co. Antrim.
1871. ‡GRANT, Sir ALEXANDER, Bart., M.A., Principal of the University of Edinburgh. 21 Lansdowne-crescent, Edinburgh.
1870. §GRANT, Colonel J. A., C.B., C.S.I., F.R.S., F.L.S., F.R.G.S. 7 Park-square West, London, N.W.
1859. ‡Grant, Hon. James. Cluny Cottage, Forres.
1855. *GRANT, ROBERT, M.A., LL.D., F.R.S., F.R.A.S., Regius Professor of Astronomy in the University of Glasgow. The Observatory, Glasgow.
1854. ‡GRANTHAM, RICHARD B., C.E., F.G.S. 22 Whitehall-place, London, S.W.
1864. ‡Grantham, Richard F. 22 Whitehall-place, London, S.W.
1874. §Graves, Rev. James, B.A., M.R.I.A. Inisnag Glebe, Stoneyford, Co. Kilkenny.
*Graves, Rev. Richard Hastings, D.D. 28A Leeson Park, Dublin.
1864. *Gray, Rev. Charles. The Vicarage, Blyth, Worksop.
1865. ‡Gray, Charles. Swan-bank, Bilston.
1870. ‡Gray, C. B. 5 Rumford-place, Liverpool.
1857. ‡Gray, Sir John, M.D. Rathgar, Dublin.
1864. ‡Gray, Jonathan. Summerhill House, Bath.
1859. ‡Gray, Rev. J. H. Bolsover Castle, Derbyshire.
1870. §Gray, J. Macfarlane. 10 York-grove, Queen's-road, Peckham, London, S.E.
1873. §Gray, William, Hon. Sec. Belfast Naturalists' Field Club. Belfast.
*GRAY, WILLIAM, F.G.S. Gray's-court, Minster Yard, York.
1861. *Gray, Colonel William. Farley Hall, near Reading.
1854. *Grazebrook, Henry. Clent Grove, near Stourbridge, Worcestershire.
1866. §Greaves, Charles Augustus, M.B., LL.B. 32 Friar-gate, Derby.
1873. §Greaves, James H., C.E. Albert-buildings, Queen Victoria-street, London, E.C.

Year of Election.

1869. §Greaves, William. Wellington-circus, Nottingham.
1872. §Greaves, William. 2 Raymond-buildings, Gray's Inn, London, W.C.
1872. *Grece, Clair J., LL.D. Redhill, Surrey.
1858. *Greenhalgh, Thomas. Sharples, near Bolton-le-Moors.
1863. ‡Greenwell, G. E. Poynton, Cheshire.
1862. *Greenwood, Henry. 32 Castle-street, and The Woodlands, Liverpool.
1849. ‡Greenwood, William. Stones, Todmorden.
1861. *Greg, Robert Philips, F.G.S., F.R.A.S. Coles Park, Buntingford, Herts.
1833. Gregg, T. H. 22 Ironmonger-lane, Cheapside, London, E.C.
1860. ‡Gregor, Rev. Walter, M.A. Pitsligo, Rosehearty, Aberdeenshire.
1868. ‡Gregory, Charles Hutton, C.E. 1 Delahay-street, Westminster, S.W.
1861. §Gregson, Samuel Leigh. Aigburth-road, Liverpool.
*Greswell, Rev. Richard, B.D., F.R.S., F.R.G.S. 39 St. Giles's-street, Oxford.
1869. ‡Grey, Sir George, F.R.G.S. Belgrave-mansions, Grosvenor-gardens, London, S.W.
1866. ‡Grey, Rev. William Hewett C. North Sherwood, Nottingham.
1863. ‡Grey, W. S. Norton, Stockton-on-Tees.
1871. *Grierson, Samuel. Medical Superintendent of the District Asylum, Melrose, N.B.
1859. ‡Grierson, Thomas Boyle, M.D. Thornhill, Dumfriesshire.
1870. ‡Grieve, John, M.D. 21 Lynedock-street, Glasgow.
*Griffin, John Joseph, F.C.S. 22 Garrick-street, London, W.C.
Griffith, Rev. C. T., D.D. Elm, near Frome, Somerset.
1859. *Griffith, George, M.A., F.C.S. (Assistant General Secretary.) Harrow.
Griffith, George R. Fitzwilliam-place, Dublin.
1868. ‡Griffith, Rev. John, M.A., D.C.L. Findon Rectory, Worthing, Sussex.
1870. ‡Griffith, N. R. The Coppa, Mold, North Wales.
1870. ‡Griffith, Rev. Professor. Bowden, Cheshire.
*Griffith, Sir Richard John, Bart., LL.D., F.R.S.E., M.R.I.A., F.G.S. 2 Fitzwilliam-place, Dublin.
1847. ‡Griffith, Thomas. Bradford-street, Birmingham.
Griffiths, Rev. John, M.A. Wadham College, Oxford.
1875. §Grignon, James, H.M. Consul at Riga. Riga.
1870. ‡Grimsdale, T. F., M.D. 29 Rodney-street, Liverpool.
1842. Grimshaw, Samuel, M.A. Errwod, Buxton.
1864. ‡Groom-Napier, Charles Ottley, F.G.S. 20 Maryland-road, Harrow-road, London, N.W.
1869. §Grote, Arthur, F.L.S., F.G.S. The Athenæum Club, Pall Mall, London, S.W.
Grove, The Hon. Sir William Robert, Knt., M.A., Ph.D., F.R.S. 115 Harley-street, London, W.
1863. *Groves, Thomas B., F.C.S. 80 St. Mary-street, Weymouth.
1869. ‡Grubb, Howard, F.R.A.S. 40 Leinster-square, Rathmines, Dublin.
1857. ‡Grubb, Thomas, F.R.S., M.R.I.A. 141 Leinster-road, Dublin.
1872. ‡Grüneisen, Charles Lewis, F.R.G.S. 16 Surrey-street, Strand, London, W.C.
Guest, Edwin, LL.D., M.A., F.R.S., F.L.S., F.R.A.S., Master of Caius College, Cambridge. Caius Lodge, Cambridge; and Sandford Park, Oxfordshire.

Year of Election.

1867. ‡Guild, John. Bayfield, West Ferry, Dundee.
Guinness, Henry. 17 College-green, Dublin.
1842. Guinness, Richard Seymour. 17 College-green, Dublin.
1856. *GUISE, Sir WILLIAM VERNON, Bart., F.G.S., F.L.S. Elmore Court, near Gloucester.
1862. ‡Gunn, Rev. John, M.A., F.G.S. Irstedd Rectory, Norwich.
1866. ‡GÜNTHER, ALBERT C. L. G., M.D., F.R.S. British Museum, London, W.C.
1868. *Gurney, John. Sprouston Hall, Norwich.
1860. *GURNEY, SAMUEL, F.L.S., F.R.G.S. 20 Hanover-terrace, Regent's Park, London, N.W.
*Gutch, John James. Holgate Lodge, York.
1859. ‡GUTHRIE, FREDERICK, B.A., F.R.S.L. & E., F.C.S., Professor of Physics in the Royal School of Mines. 24 Stanley-crescent, Notting Hill, London, W.
1864. §Guyon, George. South Cliff Cottage, Ventnor, Isle of Wight.
1870. ‡*Guyton, Joseph.*
1857. ‡Gwynne, Rev. John. Tullyagnish, Letterkenny, Strabane, Ireland.

Hackett, Michael. Brooklawn, Chapelizod, Dublin.
1865. §Hackney, William. Walter's-road, Swansea.
1866. *Hadden, Frederick J. 3 Park-terrace, Nottingham.
1866. ‡Haddon, Henry. Lenton Field, Nottingham.
Haden, G. N. Trowbridge, Wiltshire.
1865. ‡*Haden, W. H.*
1842. Hadfield, George. Victoria-park, Manchester.
1870. ‡Hadivan, Isaac. 3 Huskisson-street, Liverpool.
1848. ‡Hadland, William Jenkins. Banbury, Oxfordshire.
1870. ‡Haigh, George. Waterloo, Liverpool.
*Hailstone, Edward, F.S.A. Walton Hall, Wakefield, Yorkshire.
1869. ‡Hake, R. C. Grasmere Lodge, Addison-road, Kensington, London, W.
1870. ‡Halhead, W. B. 7 Parkfield-road, Liverpool.
HALIFAX, The Right Hon. Viscount. 10 Belgrave-square, London, S.W.; and Hickleston Hall, Doncaster.
1872. ‡Hall, Dr. Alfred. 30 Old Steine, Brighton.
1854. *HALL, HUGH FERGIE, F.G.S. Greenheys, Wallasey, Birkenhead.
1859. ‡Hall, John Frederic. Ellerker House, Richmond, Surrey.
1872. *Hall, Captain Marshall. New University Club, St. James's, London, S.W.
*Hall, Thomas B. Australia. (Care of J. P. Hall, Esq., Crane House, Great Yarmouth.)
1866. *HALL, TOWNSHEND M., F.G.S. Pilton, Barnstaple.
1860. §Hall, Walter. 10 Pier-road, Erith.
1873. §Hallett, T. G. P., M.A. Bristol.
1868. *HALLETT, WILLIAM HENRY, F.L.S. The Manor House, Kemp Town, Brighton.
1861. ‡Halliday, James. Whalley Cottage, Whalley Range, Manchester.
Halsall, Edward. 4 Somerset-street, Kingsdown, Bristol.
1858. *Hambly, Charles Hambly Burbridge, F.G.S. The Leys, Barrow-on-Soar, near Loughborough.
1866. §HAMILTON, ARCHIBALD, F.G.S. South Barrow, Bromley, Kent.
1865. §Hamilton, Gilbert. Leicester House, Kenilworth-road, Leamington.
HAMILTON, The Very Rev. HENRY PARR, Dean of Salisbury, M.A., F.R.S.L. & E., F.G.S., F.R.A.S. Salisbury.
1869. ‡Hamilton, John, F.G.S. Fyne Court, Bridgewater.
1869. §Hamilton, Roland. Oriental Club, Hanover-square, London, W.

Year of Election.

1851. ‡Hammond, C. C. Lower Brook-street, Ipswich.
1871. §Hanbury, Daniel, F.R.S. Clapham Common, London, S.W.
1863. ‡HANCOCK, ALBANY, F.L.S. 4 St. Mary's-terrace, Newcastle-upon-Tyne.
1863. ‡Hancock, John. 4 St. Mary's-terrace, Newcastle-on-Tyne.
1850. ‡Hancock, John, J.P. The Manor House, Lurgan, Co. Armagh.
1861. ‡Hancock, Walker. 10 Upper Chadwell-street, Pentonville, London, N.
1857. ‡Hancock, William J. 74 Lower Gardiner-street, Dublin.
1847. ‡HANCOCK, W. NELSON, LL.D. 74 Lower Gardiner-street, Dublin.
1865. ‡Hands, M. Coventry.
Handyside, P. D., M.D., F.R.S.E. Portobello, near Edinburgh.
1867. ‡Hannah, Rev. John, D.C.L. The Vicarage, Brighton.
1859. ‡Hannay, John. Montcoffer House, Aberdeen.
1853. ‡Hansell, Thomas T. 2 Charlotte-street, Sculcoates, Hull.
*HARCOURT, A. G. VERNON, M.A., F.R.S., F.C.S. 3 Norham-gardens, Oxford.
Harcourt, Rev. C. G. Vernon, M.A. Rothbury, Northumberland.
Harcourt, Egerton V. Vernon, M.A., F.G.S. Whitwell Hall, Yorkshire.
1865. ‡Harding, Charles. Harborne Heath, Birmingham.
1869. ‡Harding, Joseph. Hill's Court, Exeter.
1869. ‡Harding, William D. Islington Lodge, Kings Lynn, Norfolk.
1874. §Hardman, E. T., F.C.S. 14 Hume-street, Dublin.
1872. §Hardwicke, Mrs. 192 Piccadilly, London, W.
*HARE, CHARLES JOHN, M.D., Professor of Clinical Medicine in University College, London. 57 Brook-street, Grosvenor-square, London, W.
Harford, Summers. Haverfordwest.
1858. ‡Hargrave, James. Burley, near Leeds.
1853. §HARKNESS, ROBERT, F.R.S.L. & E., F.G.S., Professor of Geology in Queen's College, Cork.
1871. §Harkness, William. Laboratory, Somerset House, London, W.C.
1862. *HARLEY, GEORGE, M.D., F.R.S., F.C.S., Professor of Medical Jurisprudence in University College, London. 25 Harley-street, London, W.
*Harley, John. Ross Hall, near Shrewsbury.
1862. *HARLEY, Rev. ROBERT, F.R.S., F.R.A.S. Mill Hill School, Middlesex; and The Hawthorns, Church End, Finchley, N.
1861. ‡Harman, H. W., C.E. 16 Booth-street, Manchester.
1868. *HARMER, F. W., F.G.S. Heigham Grove, Norwich.
1872. §Harpley, Rev. William, M.A., F.C.P.S. Clayhanger Rectory, Tiverton.
*Harris, Alfred. Oxton Hall, Tadcaster.
*Harris, Alfred, jun. Lunefield, Kirkby-Lonsdale, Westmoreland.
1871. ‡HARRIS, GEORGE, F.S.A. Iselipps Manor, Northolt, Southall, Middlesex.
1863. ‡Harris, T. W. Grange, Middlesborough-on-Tees.
1873. §Harris, W. W. Oak-villas, Bradford, Yorkshire.
1860. ‡Harrison, Rev. Francis, M.A. Oriel College, Oxford.
1864. §Harrison, George. Barnsley, Yorkshire.
1873. §Harrison, George, Ph.D., F.L.S., F.C.S. 265 Glossop-road, Sheffield.
1874. §Harrison, G. D. B. Stoke Bishop, Bristol.
1858. *HARRISON, JAMES PARK, M.A. Cintra Park Villa, Upper Norwood, S.E.
1870. ‡HARRISON, REGINALD. 51 Rodney-street, Liverpool.
1853. ‡Harrison, Robert. 36 George-street, Hull.

Year of
Election.

1863. ‡Harrison, T. E. Engineers' Office, Central Station, Newcastle-on-Tyne.
1853. *Harrison, William, F.S.A., F.G.S. Samlesbury Hall, near Preston, Lancashire.
1849. ‡HARROWBY, DUDLEY RYDER, Earl of, K.G., D.C.L., F.R.S., F.R.G.S. 39 Grosvenor-square, London, S.W.; and Sandon Hall, Lichfield.
1859. *Hart, Charles. Harbourne Hall, Birmingham.
1842. *Harter, William. Hope Hall, Manchester.
1856. ‡Hartland, F. Dixon, F.S.A., F.R.G.S. The Oaklands, near Cheltenham.
Hartley, James. Sunderland.
1871. ‡Hartley, Walter Noel. King's College, London, W.C.
1854. §HARTNUP, JOHN, F.R.A.S. Liverpool Observatory, Bidston, Birkenhead.
1850. ‡Harvey, Alexander. 4 South Wellington-place, Glasgow.
1870. ‡Harvey, Enoch. Riversdale-road, Aigburth, Liverpool.
*Harvey, Joseph Charles. Knockrea, Douglas-road, Cork.
Harvey, J. R., M.D. St. Patrick's-place, Cork.
1862. *Harwood, John, jun. Woodside Mills, Bolton-le-Moors.
Hastings, Rev. H. S. Martley Rectory, Worcester.
1837. ‡Hastings, W. Huddersfield.
1842. *Hatton, James. Richmond House, Higher Broughton, Manchester.
1857. ‡HAUGHTON, Rev. SAMUEL, M.D., M.A., F.R.S., M.R.I.A., F.G.S., Professor of Geology in the University of Dublin. Trinity College, Dublin.
*Haughton, William. 28 City Quay, Dublin.
1874. §Hawkins, B. Waterhouse, F.L.S., F.G.S. Allison Tower, Dulwich, London, S.E.
Hawkins, John Heywood, M.A., F.R.S., F.G.S. Bignor Park, Petworth, Sussex.
1872. *Hawkshaw, Henry Paul. 20 King-street, St. James's, London, W.
*HAWKSHAW, Sir JOHN, F.R.S., F.G.S. (PRESIDENT ELECT.) Hollycombe, Liphook, Petersfield; and 33 Great George-street, London, S.W.
1864. *Hawkshaw, John Clarke, M.A., F.G.S. 25 Cornwall-gardens, South Kensington, S.W.; and 33 Great George-street, London, S.W.
1868. §HAWKSLEY, THOMAS, C.E., F.G.S. 30 Great George-street, London, S.W.
1863. ‡Hawthorn, William. The Cottage, Benwell, Newcastle-upon-Tyne.
1859. ‡Hay, Sir Andrew Leith, Bart. Rannes, Aberdeenshire.
1861. *HAY, Vice-Admiral the Right Hon. Sir JOHN C. D., Bart., C.B., M.P., F.R.S. 108 St. George's-square, London, S.W.
1858. ‡Hay, Samuel. Albion-place, Leeds.
1867. ‡Hay, William. 21 Magdalen-yard-road, Dundee.
1857. ‡Hayden, Thomas, M.D. 30 Harcourt-street, Dublin.
1873. *Hayes, Rev. William A., B.A. 61 George-street, Leeds.
1869. ‡Hayward, J. High-street, Exeter.
1858. *HAYWARD, ROBERT BALDWIN, M.A. The Park, Harrow.
1851. §HEAD, JEREMIAH, C.E., F.S.S. Middlesbrough, Yorkshire.
1869. ‡Head, R. T. The Briars, Alphington, Exeter.
1869. ‡Head, W. R. Bedford-circus, Exeter.
1863. ‡Heald, Joseph. 22 Leazes-terrace, Newcastle-on-Tyne.
1872. ‡Healey, C. E. H. Chadwyck. 8 Albert-mansions, Victoria-street, London, S.W.
1871. §Healey, George. Matson's, Windermere.
1861. *Heape, Benjamin. Northwood, Prestwich, near Manchester.

Year of Election.

1865. ‡Hearder, William. Victoria Parade, Torquay.
1866. ‡Heath, Rev. D. J. Esher, Surrey.
1863. ‡Heath, G. Y., M.D. Westgate-street, Newcastle-on-Tyne.
1861. §HEATHFIELD, W. E., F.C.S., F.R.G.S., F.R.S.E. 20 King-street, St. James's, London, S.W.
1865. ‡Heaton, Harry. Warstone, Birmingham.
1858. *HEATON, JOHN DEAKIN, M.D., F.R.C.P. Claremont, Leeds.
1865. ‡Heaton, Ralph. Harborne Lodge, near Birmingham.
1833. ‡HEAVISIDE, Rev. CANON J. W. L., M.A. The Close, Norwich.
1855. ‡HECTOR, JAMES, M.D., F.R.S., F.G.S., F.R.G.S., Geological Survey of New Zealand. Wellington, New Zealand.
1867. ‡HEDDLE, M. FOSTER, M.D., Professor of Chemistry in the University of St. Andrews, N.B.
1869. ‡Hedgeland, Rev. W. J. 21 Mount Radford, Exeter.
1863. ‡Hedley, Thomas. Cox Lodge, near Newcastle-on-Tyne.
1862. ‡*Helm, George F.*
1857. *Hemans, George William, C.E., M.R.I.A., F.G.S. 1 Westminster-chambers, Victoria-street, London, S.W.
1867. ‡Henderson, Alexander. Dundee.
1845. ‡Henderson, Andrew. 120 Gloucester-place, Portman-square, London, W.
1873. *Henderson, A. L. 49 King William-street, London, E.C.
1866. ‡HENDERSON, JAMES, jun. Dundee.
1874. §Henderson, James Alexander. Norwood Tower, Belfast.
1873. *HENDERSON, W. D. 12 Victoria-street, Belfast.
1856. ‡HENNESSY, HENRY, F.R.S., M.R.I.A. Mount Eagle, Sandyford, Co. Dublin.
1857. ‡Hennessy, John Pope, Governor of the Bahamas. Government House, Nassau.
1873. §Henrici, Olaus M. F. E., Ph.D., F.R.S., Professor of Mathematics in University College, London. 22 Torriano-avenue, Camden Town, London, N.W.
Henry, Franklin. Portland-street, Manchester.
Henry, J. Snowdon. East Dene, Bonchurch, Isle of Wight.
Henry, Mitchell, M.P. Stratheden House, Hyde Park, London, W.
1874. §HENRY, Rev. P. SHULDAM, D.D., M.R.I.A. President, Queen's College, Belfast.
*HENRY, WILLIAM CHARLES, M.D., F.R.S., F.G.S., F.R.G.S. Haffield, near Ledbury, Herefordshire.
1870. ‡Henty, William. Norfolk-terrace, Brighton.
HENWOOD, WILLIAM JORY, F.R.S., F.G.S. 3 Clarence-place, Penzance.
1855. *Hepburn, J. Gotch, LL.B., F.C.S. Sidcup-place, Sidcup, Kent.
1855. ‡Hepburn, Robert. 9 Portland-place, London, W.
Hepburn, Thomas. Clapham, London, S.W.
1871. ‡Hepburn, Thomas H. St. Mary's Cray, Kent.
Hepworth, John Mason. Ackworth, Yorkshire.
1856. ‡Hepworth, Rev. Robert. 2 St. James's-square, Cheltenham.
*Herbert, Thomas. The Park, Nottingham.
1852. ‡*Herdman, John.*
1866. §Herrick, Perry. Bean Manor Park, Loughborough.
1871. *HERSCHEL, Professor ALEXANDER S., B.A., F.R.A.S. College of Science, Newcastle-on-Tyne.
1874. §Herschel, Captain John, R.E., F.R.S. Collingwood, Hawkhurst, Kent.
1865. ‡Heslop, Dr. Birmingham.
1863. ‡*Heslop, Joseph.*

Year of Election.

1873. ‡Heugh, John. Holmwood, Tunbridge Wells.
1832. ‡Hewitson, William C. Oatlands, Surrey.
Hey, Rev. William, M.A., F.C.P.S. Clifton, York.
1866. *Heymann, Albert. West Bridgford, Nottinghamshire.
1866. ‡Heymann, L. West Bridgford, Nottinghamshire.
1861. *Heywood, Arthur Henry. Elleray, Windermere.
*Heywood, James, F.R.S., F.G.S., F.S.A., F.R.G.S. 26 Kensington Palace-gardens, London, W.
1861 *Heywood, Oliver. Claremont, Manchester.
Heywood, Thomas Percival. Claremont, Manchester.
1864. *Hiern, W. P., M.A. 1 Foxton-villas, Richmond, Surrey.
1854. **Higgin, Edward.*
1861. *Higgin, James. Lancaster-avenue, Fennel-street, Manchester.
Higginbotham, Samuel. 4 Springfield-court, Queen-street, Glasgow.
1866. ‡Higginbottom, John, F.R.S. Gill-street, Nottingham.
1871. ‡Higgins, Clement, B.A., F.C.S. 27 St. John's-park, Upper Holloway, London, N.
1861. ‡*Higgins, George.*
1854. ‡Higgins, Rev. Henry H., M.A. The Asylum, Rainhill, Liverpool.
1861. *Higgins, James. Stocks House, Cheetham, Manchester.
1870. ‡Higginson, Alfred. 44 Upper Parliament-street, Liverpool.
Hildyard, Rev. James, B.D., F.C.P.S. Ingoldsby, near Grantham, Lincolnshire.
Hill, Arthur. Bruce Castle, Tottenham, London, N.
1872. §Hill, Charles. Rockhurst, West Hoathley, East Grinstead.
*Hill, Rev. Edward, M.A., F.G.S. Sheering Rectory, Harlow.
1857. §Hill, John, M.I.C.E., M.R.I.A., F.R.G.S.I. County Surveyor's Office, Ennis, Ireland.
1871. ‡Hill, Lawrence. The Knowe, Greenock.
*Hill, Sir Rowland, K.C.B., D.C.L., F.R.S., F.R.A.S. Hampstead, London, N.W.
1864. ‡Hill, William. Combe Hay, Bristol.
1863 ‡Hills, F. C. Chemical Works, Deptford, Kent, S.E.
1871. §Hills, Graham H., Staff-Commander R.N. 4 Bentley-road, Princes Park, Liverpool.
1871. *Hills, Thomas Hyde. 338 Oxford-street, London, W.
1858. ‡Hincks, Rev. Thomas, B.A., F.R.S. Charlemont, Taunton.
1870. ‡Hinde, G. J. Buenos Ayres.
Hindley, Rev. H. J. Edlington, Lincolnshire.
1852. *Hindmarsh, Frederick, F.G.S., F.R.G.S. 4 New Inn, Strand, London, W.C.
*Hindmarsh, Luke. Alnbank House, Alnwick.
1865. ‡Hinds, James, M.D. Queen's College, Birmingham.
1863. ‡Hinds, William, M.D. Parade, Birmingham.
1861. *Hinmers, William. Cleveland House, Birkdale, Southport.
1858. §Hirst, John, jun. Dobcross, near Manchester.
1861. *Hirst, T. Archer, Ph.D., F.R.S., F.R.A.S. Royal Naval College, Greenwich, S.E.; and Athenæum Club, Pall Mall, London, S.W.
1856. ‡Hitch, Samuel, M.D. Sandywell Park, Gloucestershire.
1870. ‡Hitchman, William, M.D., LL.D., F.L.S., &c. 29 Erskine-street, Liverpool.
*Hoare, Rev. George Tooker. Godstone Rectory, Redhill.
Hoare, J. Gurney. Hampstead, London, N.W.
1864. ‡Hobhouse, Arthur Fane. 24 Cadogan-place, London, S.W.
1864. ‡Hobhouse, Charles Parry. 24 Cadogan-place, London, S.W.

Year of Election.

1864. ‡Hobhouse, Henry William. 24 Cadogan-place, London, S.W.
1863. §Hobson, A. S., F.C.S. 3 Upper Heathfield-terrace, Turnham Green, London, W.
1866. ‡Hockin, Charles, M.D. 8 Avenue-road, St. John's Wood, London, N.W.
1852. ‡Hodges, John F., M.D., F.C.S., Professor of Agriculture in Queen's College, Belfast.
1863. *Hodgkin, Thomas. Benwell Dene, Newcastle-on-Tyne.
1873. *Hodgson, George. Thornton-road, Bradford, Yorkshire.
1873. ‡Hodgson, James. Oakfield, Manningham, Bradford, Yorkshire.
1863. ‡Hodgson, Robert. Whitburn, Sunderland.
1863. ‡Hodgson, R. W. North Dene, Gateshead.
1839. ‡Hodgson, W. B., LL.D., F.R.A.S. 41 Grove-end-road, St. John's Wood, London, N.W.
1865. *Hofmann, Augustus William, LL.D., Ph.D., F.R.S., F.C.S. 10 Dorotheen Strasse, Berlin.
1860. ‡Hogan, Rev. A. R., M.A. Watlington Vicarage, Oxfordshire.
1854. *Holcroft, George. Byron's-court, St. Mary's-gate, Manchester.
1873. *Holden, Isaac. Oakworth House, near Keighley, Yorkshire.
1856. ‡Holland, Henry. Dumbleton, Evesham.
1858. §Holland, Loton, F.R.G.S. The Gables, Osborne-road, Windsor.
*Holland, Philip H. 41 Parliament-street, Westminster, S.W.
1865. ‡Holliday, William. New-street, Birmingham.
*Hollingsworth, John, M.R.C.S. Maidenstone House, Maidenstone-hill, Greenwich, S.E.
1866. *Holmes, Charles. 59 London-road, Derby.
1873. ‡Holmes, J. R. Southbrook Lodge, Bradford, Yorkshire.
1870. ‡Holt, William D. 23 Edge-lane, Liverpool.
*Hone, Nathaniel, M.R.I.A. Bank of Ireland, Dublin.
1858. ‡Hook, The Very Rev. W. F., D.D., F.R.S., Dean of Chichester. Chichester.
1847. ‡Hooker, Joseph Dalton, C.B., M.D., D.C.L., LL.D., Pres. R.S., V.P.L.S., F.G.S., F.R.G.S. Royal Gardens, Kew, W.
1865. *Hooper, John P. The Hut, Mitcham Common, Surrey.
1861. §Hooper, William. 7 Pall Mall East, London, S.W.
1856. ‡Hooton, Jonathan. 80 Great Ducie-street, Manchester.
1842. Hope, Thomas Arthur. Stanton, Bebington, Cheshire.
1869. ‡Hope, William, V.C. Parsloes, Barking, Essex.
1865. ‡Hopkins, J. S. Jesmond Grove, Edgbaston, Birmingham.
1870. *Hopkinson, John. Woodlea, Beech-lanes, Birmingham.
1871. §Hopkinson, John, F.G.S., F.R.M.S. Holly Bank, Watford.
1858. ‡Hopkinson, Joseph, jun. Britannia Works, Huddersfield.
Hornby, Hugh. Sandown, Liverpool.
1858. *Horsfall, Abraham. Manor House, Whitkirks, near Leeds.
1854. ‡Horsfall, Thomas Berry. Bellamour Park, Rugeley.
1856. ‡Horsley, John H. 389 High-street, Cheltenham.
Hotham, Rev. Charles, M.A., F.L.S. Roos, Patrington, Yorkshire.
1868. ‡Hotson, W. C. Upper King-street, Norwich.
1859. ‡*Hough, Joseph.*
Houghton, The Right Hon. Lord, M.A., D.C.L., F.R.S., F.R.G.S. 16 Upper Brook-street, London, W.
Houghton, James. 41 Rodney-street, Liverpool.
1858. ‡Hounsfield, James. Hemsworth, Pontefract.
Hovenden, W. F., M.A. Bath.
1859. ‡Howard, Captain John Henry, R.N. The Deanery, Lichfield.
1863. ‡Howard, Philip Henry. Corby Castle, Carlisle.

Year of Election

1857. ‡Howell, Henry H., F.G.S. Museum of Practical Geology, Jermyn-street, London, S.W.
1868. ‡HOWELL, Rev. Canon HINDS. Drayton Rectory, near Norwich.
1865. *HOWLETT, Rev. FREDERICK, F.R.A.S. East Tisted Rectory, Alton, Hants.
1863. ‡HOWORTH, H. H. Derby House, Eccles, Manchester.
1854. ‡Howson, The Very Rev. J. S., D.D., Dean of Chester. Chester.
1870. ‡Hubback, Joseph. 1 Brunswick-street, Liverpool.
1835. *HUDSON, HENRY, M.D., M.R.I.A. Glenville, Fermoy, Co. Cork.
1842. §Hudson, Robert, F.R.S., F.G.S., F.L.S. Clapham Common, London, S.W.
1867. ‡Hudson, William H. H., M.A. 19 Bennett's-hill, Doctors' Commons, London, E.C.; and St. John's College, Cambridge.
1858. *HUGGINS, WILLIAM, D.C.L. Oxon., LL.D. Camb., F.R.S., F.R.A.S. Upper Tulse-hill, Brixton, London, S.W.
1857. ‡Huggon, William. 30 Park-row, Leeds.
Hughes, D. Abraham.
1871. *Hughes, George Pringle, J. P. Middleton Hall, Wooler, Northumberland.
1870. *Hughes, Lewis. Fenwick-court, Liverpool.
1868. §HUGHES, T. M'K., M.A., F.G.S., Woodwardian Professor of Geology in the University of Cambridge.
1863. ‡Hughes, T. W. 4 Hawthorn-terrace, Newcastle-on-Tyne.
1865. ‡Hughes, W. R., F.L.S., Treasurer of the Borough of Birmingham. Birmingham.
Hull, Arthur H. 18 Norfolk-road, Brighton.
1867. §HULL, EDWARD, M.A., F.R.S., F.G.S. Director of the Geological Survey of Ireland, and Professor of Geology in the Royal College of Science. 14 Hume-street, Dublin.
*Hull, William Darley. Stenton Lodge, Tunbridge Wells.
*Hulse, Sir Edward, Bart., D.C.L. 47 Portland-place, London, W.; and Breamore House, Salisbury.
1861. ‡HUME, Rev. ABRAHAM, D.C.L., LL.D., F.S.A. All Souls' Vicarage, Rupert-lane, Liverpool.
1856. ‡Humphries, David James. 1 Keynsham-parade, Cheltenham.
1862. *HUMPHRY, GEORGE MURRAY, M.D., F.R.S., Professor of Anatomy in the University of Cambridge. The Leys, Cambridge.
1863. *HUNT, AUGUSTUS H., M.A., Ph.D. Birtley House, near Chester-le-Street.
1865. ‡Hunt, J. P. Gospel Oak Works, Tipton.
1840. ‡HUNT, ROBERT, F.R.S., Keeper of the Mining Records. Museum of Practical Geology, Jermyn-street, London, S.W.
1864. ‡Hunt, W. 72 Pulteney-street, Bath.
Hunter, Andrew Galloway. Denholm, Hawick, N.B.
1868. ‡Hunter, Christopher. Alliance Insurance Office, North Shields.
1867. ‡Hunter, David. Blackness, Dundee.
1869. *Hunter, Rev. Robert, F.G.S. 9 Mecklenburgh-street, London, W.C.
1855. *Hunter, Thomas O. 13 William-street, Greenock.
1863. ‡Huntsman, Benjamin. West Retford Hall, Retford.
1869. ‡Hurst, George. Bedford.
1861. *Hurst, William John. Drumaness Mills, Ballynahinch, Lisburn, Ireland.
1870. ‡Hurter, Dr. Ferdinand. Appleton, Widnes, near Warrington.
Husband, William Dalla. Coney-street, York.
1874. §Hutchinson, Thomas J., F.R.G.S. Chimoo Cottage, Mill Hill, London, N.W.
1868. *Hutchison, Robert, F.R.S.E. Carlowrie, Kirkliston, N.B.
1863. ‡HUTT, The Right Hon. Sir W., K.C.B. Gibside, Gateshead.

Year of Election.

Hutton, Crompton. Putney-park, Surrey, S.W.
1864. *Hutton, Darnton. (Care of Arthur Lupton, Esq., Headingley, near Leeds.)
Hutton, Henry. Edenfield, Dundrum, Co. Dublin.
1857. ‡Hutton, Henry D. 10 Lower Mountjoy-street, Dublin.
1861. *Hutton, T. Maxwell. Summerhill, Dublin.
1852. ‡HUXLEY, THOMAS HENRY, Ph.D., LL.D., Sec. R.S., F.L.S., F.G.S., Professor of Natural History in the Royal School of Mines. 4 Marlborough-place, London, N.W.
Hyde, Edward. Dukinfield, near Manchester.
1871. *Hyett, Francis A. 13 Hereford-square, Old Brompton, London, S.W.
Hyett, William Henry, F.R.S. Painswick, near Stroud, Gloucestershire.

Ihne, William, Ph.D. Heidelberg.
1873. §Ikin, T. J. 19 Park-place, Leeds.
1861. ‡Iles, Rev. J. H. Rectory, Wolverhampton.
1858. ‡Ingham, Henry. Wortley, near Leeds.
1871. ‡INGLIS, The Right Hon. JOHN, D.C.L., LL.D., Lord Justice General of Scotland. Edinburgh.
1858. *Ingram, Hugo Francis Meynell. Temple Newsam, Leeds.
1852. ‡INGRAM, J. K., LL.D., M.R.I.A., Regius Professor of Greek. Trinity College, Dublin.
1854. *INMAN, THOMAS, M.D. 8 Vyvyan-terrace, Clifton, Bristol.
1870. *Inman, William. Upton Manor, Liverpool.
Ireland, R. S., M.D. 121 Stephen's-green, Dublin.
1857. ‡Irvine, Hans, M.A., M.B. 1 Rutland-square, Dublin.
1862. ‡ISELIN, J. F., M.A., F.G.S. 52 Stockwell Park-road, London, S.W.
1863. *Ivory, Thomas. 23 Walker-street, Edinburgh.

1865. ‡Jabet, George. Wellington-road, Handsworth, Birmingham.
1870. ‡Jack, James. 26 Abercromby-square, Liverpool.
1859. §Jack, John, M.A. Belhelvie-by-Whitecairns, Aberdeenshire.
1866. §Jackson, H. W., F.R.A.S., F.G.S. 15 The Terrace, High-road, Lewisham, S.E.
1869. §Jackson, Moses. The Vale, Ramsgate.
Jackson, Professor Thomas, LL.D. St. Andrew's, Scotland.
1863. *Jackson-Gwilt, Mrs. H. 24 Hereford-square, Gloucester-road, Brompton, London, S.W.
1852. ‡JACOBS, BETHEL. 40 George-street, Hull.
1874. *Jaffe, John. Messrs. Jaffe Brothers, Belfast.
1865. *Jaffray, John. Park-grove, Edgbaston, Birmingham.
1872. §James, Christopher. 8 Laurence Pountney Hill, London, E.C.
1859. ‡James, Edward. 9 Gascoyne-terrace, Plymouth.
1860. ‡James, Edward H. 9 Gascoyne-terrace, Plymouth.
JAMES, Major-General Sir HENRY, R.E., F.R.S., F.G.S., M.R.I.A. Ordnance Survey Office, Southampton.
1863. *JAMES, Sir WALTER, Bart., F.G.S. 6 Whitehall-gardens, London, S.W.
1858. ‡James, William C. 9 Gascoyne-terrace, Plymouth.
1863. ‡Jameson, John Henry. 10 Catherine-terrace, Gateshead.
1859. *Jamieson, Thomas F., F.G.S. Ellon, Aberdeenshire.
1850. ‡Jardine, Alexander. Jardine Hall, Lockerby, Dumfriesshire.
1870. ‡Jardine, Edward. Beach Lawn, Waterloo, Liverpool.
1853. *Jarratt, Rev. Canon J., M.A. North Cave, near Brough, Yorkshire.
JARRETT, Rev. THOMAS, M.A., Professor of Arabic in the University of Cambridge. Trunch, Norfolk.

Year of Election.

1870. §Jarrold, John James. London-street, Norwich.
1862. ‡Jeakes, Rev. James, M.A. 54 Argyll-road, Kensington, W.
Jebb, Rev. John. Peterstow Rectory, Ross, Herefordshire.
1868. ‡Jecks, Charles. Billing-road, Northampton.
1870. ‡*Jeffery, F. J. Liverpool.*
1856. ‡Jeffery, Henry, M.A. 438 High-street, Cheltenham.
1855. *Jeffray, John. Cardowan House, Millerston, Glasgow.
1867. ‡Jeffreys, Howel, M.A., F.R.A.S. 5 Brick-court, Temple, E.C.; and 25 Devonshire-place, Portland-place, London, W.
1861. *Jeffreys, J. Gwyn, LL.D., F.R.S., F.L.S., Treas. G.S., F.R.G.S. Ware Priory, Herts.
1852. ‡Jellett, Rev. John H., M.A., M.R.I.A., Professor of Natural Philosophy in Trinity College, Dublin. 64 Upper Leeson-street, Dublin.
1842. Jellicorse, John. Chaseley, near Rugeley, Staffordshire.
1862. §Jenkin, H. C. Fleeming, F.R.S., M.I.C.E., Professor of Civil Engineering in the University of Edinburgh. 5 Fettes-row, Edinburgh.
1864. §Jenkins, Captain Griffith, C.B., F.R.G.S. Derwin, Welshpool.
1873. §Jenkins, Major General J. J. 14 St. James's-square, London, S.W.
*Jenkyns, Rev. Henry, D.D. The College, Durham.
Jennette, Matthew. 106 Conway-street, Birkenhead.
1852. ‡Jennings, Francis M., F.G.S., M.R.I.A. Brown-street, Cork.
1872. ‡Jennings, W. Grand Hotel, Brighton.
1870. ‡Jerdon, T. C. (Care of Mr. H. S. King, 45 Pall Mall, London, S.W.)
*Jerram, Rev. S. John, M.A. Chobham Vicarage, near Bagshot, Surrey.
1872. §Jesson, Thomas. (Care of Messrs. G. White & Co., 23 Rood-lane, London, E.C.)
Jessop, William, jun. Butterley Hall, Derbyshire.
1870. *Jevons, W. Stanley, M.A., F.R.S., Professor of Logic and Political Economy in Owens College, Manchester. 36 Parsonage-road, Withington, Manchester.
1872. *Joad, George C. Patching, Arundel, Sussex.
1871. *Johnson, David, F.C.S., F.G.S. Irvon Villa, Grosvenor-road, Wrexham.
1865. *Johnson, G. J. 34 Waterloo-street, Birmingham.
1866. §Johnson, John. Knighton Fields, Leicester.
1866. ‡Johnson, John G. 18A Basinghall-street, London, E.C.
1868. ‡Johnson, J. Godwin. St. Giles's-street, Norwich.
1872. ‡Johnson, J. T. 27 Dale-street, Manchester.
1868. ‡*Johnson, Randall J.*
1861. ‡Johnson, Richard. 27 Dale-street, Manchester.
1870. §Johnson, Richard C. Warren Side, Blundell Sands, Liverpool.
1863. ‡Johnson, R. S. Hanwell, Fence Houses, Durham.
*Johnson, Thomas. The Hermitage, Frodsham, Cheshire.
1864. ‡*Johnson, Thomas.*
Johnson, William. The Wynds Point, Colwall, Malvern, Worcestershire.
1861. ‡Johnson, William Beckett. Woodlands Bank, near Altrincham.
1871. ‡Johnston, A. Keith, F.R.G.S. 1 Savile-row, London, W.
1864. ‡Johnston, David. 13 Marlborough-buildings, Bath.
1864. ‡*Johnston, Edward.*
1859. ‡Johnston, James. Newmill, Elgin, N.B.
1864. ‡Johnston, James. Manor House, Northend, Hampstead, London, N.W.
*Johnstone, James. Alva House, by Stirling, N.B.
1864. ‡Johnstone, John. 1 Barnard-villas, Bath.

Year of Election.

1864. ‡Jolly, Thomas. Park View-villas, Bath.
1871. §Jolly, William (H.M. Inspector of Schools). Inverness, N.B.
1849. ‡Jones, Baynham. Selkirk Villa, Cheltenham.
1856. ‡Jones, C. W. 7 Grosvenor-place, Cheltenham.
1854. ‡*Jones, Rev. Henry H.*
1854. ‡*Jones, John.*
1864. §JONES, JOHN, F.G.S. Saltburn-by-the-Sea, Yorkshire.
1865. ‡Jones, John. 49 Union-passage, Birmingham.
*Jones, Robert. 2 Castle-street, Liverpool.
1854. *Jones, R. L. 6 Sunnyside, Princes Park, Liverpool.
1873. ‡Jones, Theodore B. 1 Finsbury-circus, London, E.C.
1860. ‡JONES, THOMAS RUPERT, F.R.S., F.G.S., Professor of Geology and Mineralogy, Royal Military and Staff Colleges, Sandhurst. 5 College-terrace, York Town, Surrey.
1847. ‡JONES, THOMAS RYMER, F.R.S., Professor of Comparative Anatomy in King's College. 52 Cornwall-road, Westbourne Park, London, W.
1864. §JONES, Sir WILLOUGHBY, Bart., F.R.G.S. Cranmer Hall, Fakenham, Norfolk.
*Joule, Benjamin St. John B. Southcliffe, Southport, Lancashire.
1842. *JOULE, JAMES PRESCOTT, LL.D., F.R.S., F.C.S. 343 Lower Broughton-road, Manchester.
1847. ‡JOWETT, Rev. B., M.A., Regius Professor of Greek in the University of Oxford. Balliol College, Oxford.
1858. ‡Jowett, John. Leeds.
1872. ‡Joy, Algernon. 17 Parliament-street, Westminster, S.W.
1848. *Joy, Rev. Charles Ashfield. Grove Parsonage, Wantage, Berkshire.
Joy, Henry Holmes, LL.D., Q.C., M.R.I.A. Torquay.
Joy, Rev. John Holmes, M.A. 3 Coloney-terrace, Tunbridge Wells.
*Jubb, Abraham. Halifax.
1870. ‡Judd, John Wesley, F.G.S. 6 Manor-view, Brixton, London, S.W.
1863. ‡Jukes, Rev. Andrew. Spring Bank, Hull.

1868. *Kaines, Joseph, M.A., D.Sc., F.A.S.L. 8 Osborne-road, Stroud Green-lane, Hornsey, London, N.
KANE, Sir ROBERT, M.D., F.R.S., M.R.I.A., Principal of the Royal College of Cork. 51 Stephen's-green, Dublin.
1857. ‡Kavanagh, James W. Grenville, Rathgar, Ireland.
1859. ‡Kay, David, F.R.G.S. 19 Upper Phillimore-place, Kensington, London, W.
Kay, John Cunliff. Fairfield Hall, near Skipton.
*Kay, John Robinson. Walmersley House, Bury, Lancashire.
Kay, Robert. Haugh Bank, Bolton-le-Moors.
1847. *Kay, Rev. William, D.D. Great Leghs Rectory, Chelmsford.
1856. ‡Kay-Shuttleworth, Sir James, Bart. Gawthorpe, Burnley.
1855. ‡Kaye, Robert. Mill Brae, Moodies Burn, by Glasgow.
1872. ‡Keames, William M. 5 Lower-rock-gardens, Brighton.
1855. ‡*Keddie, William.*
1866. ‡Keene, Alfred. Eastnoor House, Leamington.
1850. ‡KELLAND, Rev. PHILIP, M.A., F.R.S. L. & E., Professor of Mathematics in the University of Edinburgh. 20 Clarendon-crescent, Edinburgh.
1864. *Kelly, W. M., M.D. 11 The Crescent, Taunton, Somerset.
1853. ‡Kemp, Rev. Henry William, B.A. The Charter House, Hull.
1857. ‡Kennedy, Lieut-Colonel John Pitt. 20 Torrington-square, Bloomsbury, London, W.C.
Kenny, Matthias. 3 Clifton-terrace, Monkstown, Co. Dublin.

Year of
Election.

1865. ‡Kenrick, William. Norfolk-road, Edgbaston, Birmingham.
Kent, J. C. Levant Lodge, Earl's Croome, Worcester.
1857. ‡Kent, William T., M.R.D.S. 51 Rutland-square, Dublin.
1857. ‡Kenworth, James Ryley. 7 Pembroke-place, Liverpool.
1857. *Ker, André Allen Murray. Newbliss House, Newbliss, Ireland.
1855. *Ker, Robert. Auchinraith, near Hamilton, Scotland.
1865. *Kerr, William D., M.D., R.N. 3 Duncan-street, Drummond-place, Edinburgh.
1868. ‡Kerrison, Roger. Crown Bank, Norwich.
1869. *Kesselmeyer, Charles A. 1 Peter-street, Manchester.
1869. *Kesselmeyer, William Johannes. 1 Peter-street, Manchester.
1861. *Keymer, John. Parker-street, Manchester.
1865. *Kinahan, Edward Hudson. 11 Merrion-square North, Dublin.
1860. ‡KINAHAN, G. HENRY, M.R.I.A., Geological Survey of Ireland. 14 Hume-street, Dublin.
1858. ‡Kincaid, Henry Ellis, M.A. 8 Lyddon-terrace, Leeds.
1872. *King, Mrs. E. M. 34 Cornwall-road, Westbourne-park, London, W.
1871. *King, Herbert Poole. Theological College, Salisbury.
1855. ‡King, James. Levernholme, Hurlet, Glasgow.
1870. ‡King, John Thomson, C.E. 4 Clayton-square, Liverpool.
King, Joseph. Blundell Sands, Liverpool.
1864. §KING, KELBURNE, M.D. 27 George-street, and Royal Institution, Hull.
1860. *King, Mervyn Kersteman. 16 Vyvyan-terrace, Clifton, Bristol.
1842. KING, RICHARD, M.D. 12 Bulstrode-street, London, W.
King, Rev. Samuel, M.A., F.R.A.S. St. Aubins, Jersey.
1870. ‡King, William. 13 Adelaide-terrace, Waterloo, Liverpool.
King, William Poole, F.G.S. Avonside, Clifton, Bristol.
1869. ‡Kingdon, K. Taddiford, Exeter.
1861. ‡Kingsley, John. Ashfield, Victoria Park, Manchester.
1835. Kingstone, A. John, M.A. Mosstown, Longford, Ireland.
1867. ‡Kinloch, Colonel. Kirriemuir, Logie, Scotland.
1867. *KINNAIRD, The Hon. ARTHUR FITZGERALD, M.P. 1 Pall Mall East, London, S.W.; and Rossie Priory, Inchture, Perthshire.
1863. ‡KINNAIRD, The Right Hon. Lord., K.T., F.G.S. Rossie Priory, Inchture, Perthshire.
Kinnear, J. G., F.R.S.E.
1870. ‡Kinsman, William R. Branch Bank of England, Liverpool.
1863. ‡Kirkaldy, David. 28 Bartholomew-road North, London, N.W.
1860. ‡KIRKMAN, Rev. THOMAS P., M.A., F.R.S. Croft Rectory, near Warrington.
Kirkpatrick, Rev. W. B., D.D. 48 North Great George-street, Dublin.
1870. ‡Kitchener, Frank E. Rugby.
1869. ‡Knapman, Edward. The Vineyard, Castle-street, Exeter.
1870. §Kneeshaw, Henry. 2 Gambier-terrace, Liverpool.
1836. Knipe, J. A. Botcherby, Carlisle.
1872. *Knott, George, LL.B., F.R.A.S. Cuckfield, Hayward's Heath, Sussex.
1873. *Knowles, George. Moorhead, Shipley, Yorkshire.
1872. ‡Knowles, James. The Hollies, Clapham Common, S.W.
1842. Knowles, John. Old Trafford Bank House, Old Trafford, Manchester.
1870. ‡*Knowles, Rev. J. L.*
1874. §Knowles, William James. Cullybackey, Ballymena, Ireland.
*Knox, George James. 2 Portland-terrace, Regent's Park, London, N.W.
1835. Knox, Thomas B. Union Club, Trafalgar-square, London, W.C.

Year of Election.

1870. ‡Kynaston, Josiah W. St. Helens, Lancashire.
1865. ‡Kynnersley, J. C. S. The Leveretts, Handsworth, Birmingham.

1858. §Lace, Francis John. Stone Gapp, Cross-hill, Leeds.
1862. ‡*Lackerstein, Dr.*
1859. §Ladd, William, F.R.A.S. 11 & 13 Beak-street, Regent-street, London, W.
1850. ‡Laing, David, F.S.A. Scotl. Signet Library, Edinburgh.
1870. ‡Laird, H. H. Birkenhead.
Laird, John, M.P. Hamilton-square, Birkenhead.
1870. §Laird, John, jun. Grosvenor-road, Claughton, Birkenhead.
1859. ‡Lalor, John Joseph, M.R.I.A. 2 Longford-terrace, Monkstown, Co. Dublin.
1846. *Laming, Richard. Flansham, near Bognor, Sussex.
1870. ‡Lamport, Charles. Upper Norwood, Surrey, S.E.
1871. §Lancaster, Edward. Karesforth Hall, Barnsley, Yorkshire.
1859. ‡Lang, Rev. John Marshall. Bank House, Morningside, Edinburgh.
1864. §Lang, Robert. Mancombe, Henbury, Bristol.
1870. ‡Langton, Charles. Barkhill, Aigburth, Liverpool.
*Langton, William. Manchester and Salford Bank, Manchester.
1865. §LANKESTER, E. RAY, M.A. Exeter College, Oxford.
Lanyon, Sir Charles. The Abbey, White Abbey, Belfast.
*LARCOM, Major-General Sir THOMAS AISKEW, Bart., K.C.B., R.E., F.R.S., M.R.I.A. Heathfield House, Fareham, Hants.
LASSELL, WILLIAM, F.R.S., F.R.A.S. Ray Lodge, Maidenhead.
1861. *Latham, Arthur G. Lower King-street, Manchester.
1870. *Latham, Baldwin. 7 Westminster-chambers, Westminster, S.W.
1845. ‡Latham, Robert G., M.A., M.D., F.R.S. 96 Disraeli-road, Putney, S.W.
1870. ‡Laughton, John Knox, M.A., F.R.A.S., F.R.G.S. Royal Naval College, Portsmouth.
1870. *Law, Channell. 5 Champion-park, Camberwell, London, S.E.
1857. ‡Law, Hugh, Q.C. 4 Great Denmark-street, Dublin.
1862. ‡Law, Rev. James Edmund, M.A. Little Shelford, Cambridgeshire.
Lawley, The Hon. Francis Charles. Escrick Park, near York.
Lawley, The Hon. Stephen Willoughby. Escrick Park, near York.
1870. ‡Lawrence, Edward. Aigburth, Liverpool.
1869. ‡Lawson, Henry. 8 Nottingham-place, London, W.
1857. ‡Lawson, The Right Hon. James A., LL.D., M.R.I.A. 27 Fitzwilliam-street, Dublin.
1868. *LAWSON, M. ALEXANDER, M.A., F.L.S., Professor of Botany in the University of Oxford. Botanic Gardens, Oxford.
1863. ‡Lawton, Benjamin C. Neville Chambers, 44 Westgate-street, Newcastle-upon-Tyne.
1853. ‡Lawton, William. 5 Victoria-terrace, Derringham, Hull.
LAYCOCK, THOMAS, M.D., Professor of the Practice of Physic in the University of Edinburgh. 4 Rutland-street, Edinburgh.
1865. ‡Lea, Henry. 35 Paradise-street, Birmingham.
1857. ‡Leach, Capt. R. E. Mountjoy, Phœnix Park, Dublin.
1870. *Leaf, Charles John, F.L.S., F.G.S., F.S.A. Old Change, London, E.C.; and Painshill, Cobham.
1847. *LEATHAM, EDWARD ALDAM, M.P. Whitley Hall, Huddersfield; and 46 Eaton-square, London, S.W.
*Leather, John Towlerton, F.S.A. Leventhorpe Hall, near Leeds.
1858. ‡Leather, John W. Newton Green, Leeds.
1863. ‡Leavers, J. W. The Park, Nottingham.
1872. ‡LEBOUR, G. A., F.G.S. Weedpark House, Dipton, Lintz Green, Co. Durham.

Year of Election.

1858. *Le Cappelain, John. Wood-lane, Highgate, London, N.
1858. ‡Ledgard, William. Potter Newton, near Leeds.
1842. Lee, Daniel. Springfield House, Pendlebury, Manchester.
1861. ‡Lee, Henry. Irwell House, Lower Broughton, Manchester.
1853. *LEE, JOHN EDWARD, F.G.S., F.S.A. Villa Syracusa, Torquay.
1859. ‡Lees, William. Link Vale Lodge, Viewforth, Edinburgh.
*Leese, Joseph. Glenfield, Altrincham, Manchester.
*Leeson, Henry B., M.A., M.D., F.R.S., F.C.S The Maples, Bonchurch, Isle of Wight.
1872. ‡LEFEVRE, G. SHAW, M.P., F.R.G.S. 18 Spring-gardens, London, S.W.
*LEFROY, Major-General J. HENRY, R.A., F.R.S., F.R.G.S., Governor of Bermuda. Bermuda.
*Legh, Lieut.-Colonel George Cornwall, M.P. High Legh Hall, Cheshire; and 43 Curzon-street, Mayfair, London, W.
1869. ‡Le Grice, A. J. Trereife, Penzance.
1868. ‡LEICESTER, The Right Hon. the Earl of. Holkham, Norfolk.
1856. ‡LEIGH, The Right Hon. Lord, D.C.L. 37 Portman-square, London, W.; and Stoneleigh Abbey, Kenilworth.
1861. *Leigh, Henry. Moorfield, Swinton, near Manchester.
1870. ‡Leighton, Andrew. 35 High-park-street, Liverpool.
1867. §Leishman, James. Gateacre Hall, Liverpool.
1870. ‡Leister, G. F. Gresbourn House, Liverpool.
1859. ‡Leith, Alexander. Glenkindie, Inverkindie, N.B.
1860. ‡Lempriere, Charles, D.C.L. St. John's College, Oxford.
1863. *LENDY, Capt. AUGUSTE FREDERIC, F.L.S., F.G.S. Sunbury House, Sunbury, Middlesex.
1867. ‡Leng, John. 'Advertiser' Office, Dundee.
1861. ‡Lennox, A. C. W. 7 Beaufort-gardens, Brompton, London, S.W.
Lentaigne, John, M.D. Tallaght House, Co. Dublin; and 14 Great Dominick-street, Dublin.
Lentaigne, Joseph. 12 Great Denmark-street, Dublin.
1871. §LEONARD, HUGH, M.R.I.A., Geological Survey of Ireland. 14 Hume-street, Dublin.
1874. §Lepper, Charles W. Laurel Lodge, Belfast.
1861. ‡Leppoc, Henry Julius. Kersal Crag, near Manchester.
1872. §Lermit, Rev. Dr. School House, Dedham.
1871. ‡Leslie, Alexander, C.E. 72 George-street, Edinburgh.
1856. ‡Leslie, Colonel J. Forbes. Rothienorman, Aberdeenshire.
1852. ‡LESLIE, T. E. CLIFFE, LL.B., Professor of Jurisprudence and Political Economy, Queen's College, Belfast.
1866. §LEVI, Dr. LEONE, F.S.A., F.S.S., F.R.G.S., Professor of Commercial Law in King's College, London. 10 Farrar's-building, Temple, London, E.C.
1870. ‡Lewis, Alfred Lionel. 151 Church-road, De Beauvoir Town, London, N.
1853. ‡Liddell, George William Moore. Sutton House, near Hull.
1860. ‡LIDDELL, The Very Rev. H. G., D.D., Dean of Christ Church, Oxford.
1855. ‡*Liddell, John.*
1874. §Lidden, W. A. Clifton College, Bristol.
1859. ‡*Ligertwood, George.*
1864. ‡LIGHTBODY, ROBERT, F.G.S. Ludlow, Salop.
1862. ‡LILFORD, The Right Hon. Lord, F.L.S. Lilford Hall, Oundle, Northamptonshire.
*LIMERICK, CHARLES GRAVES, D.D., M.R.I.A., Lord Bishop of. The Palace, Henry-street, Limerick.
*Lindsay, Charles. Ridge Park, Lanark, N.B.

Year of Election.

1855. *_Lindsay, John H._
1871. *LINDSAY, The Right Hon. Lord, M.P. 47 Brook-street, London, W.
1871. ‡Lindsay, Rev. T. M. 7 Great Stuart-street, Edinburgh.
1870. ‡Lindsay, Thomas. 288 Renfrew-street, Glasgow.
1842 *Lingard, John R., F.G.S. Mayfield, Shortlands, Bromley, Kent.
Lingwood, Robert M., M.A., F.L.S., F.G.S. 1 Derby-villas, Cheltenham.
Lister, James. Liverpool Union Bank, Liverpool.
1873. *Lister, Samuel Cunliffe. Farfield Hall, Addingham, Leeds.
1870. §Lister, Thomas. Victoria-crescent, Barnsley.
Littledale, Harold. Liscard Hall, Cheshire.
1861. *LIVEING, G. D., M.A., F.C.S., Professor of Chemistry in the University of Cambridge. Newnham, Cambridge.
1864. §Livesay, J. G. Cromarty House, Ventnor, Isle of Wight.
1860. ‡Livingstone, Rev. Thomas Gott, Minor Canon of Carlisle Cathedral.
Lloyd, Rev. A. R. Hengold, near Oswestry.
Lloyd, Rev. C., M.A. Whittington, Oswestry.
1842. Lloyd, Edward. King-street, Manchester.
1865. ‡Lloyd, G. B. Wellington-road, Edgbaston, Birmingham.
*Lloyd, George, M.D., F.G.S. Park Glass Works, Birmingham.
*LLOYD, Rev. HUMPHREY, D.D., LL.D., F.R.S. L. & E., M.R.I.A., Provost of Trinity College, Dublin.
1870. ‡Lloyd, James. 16 Welfield-place, Liverpool.
1870. ‡Lloyd, J. H., M.D. Anglesey, North Wales.
1865. ‡Lloyd, John. Queen's College, Birmingham.
Lloyd, Rev. Rees Lewis. Belper, Derbyshire.
1865. *Lloyd, Wilson. Myrod House, Wednesbury.
1854. *LOBLEY, JAMES LOGAN, F.G.S., F.R.G.S. 59 Clarendon-road, Kensington, London, W.
1853. *Locke, John. (Care of J. Robertson, Esq., 3 Grafton-street, Dublin.)
1867. *Locke, John. 83 Addison-road, Kensington, London, W.
1872. ‡LOCKE, JOHN, M.P. 63 Eaton-place, London, S.W.
1863. ‡LOCKYER, J. NORMAN, F.R.S., F.R.A.S. 5 Alexandra-road, Finchley-road, London, N.W.
1875. *Lodge, Oliver J. Hanley, Staffordshire.
*LOGAN, Sir WILLIAM EDMOND, LL.D., F.R.S., F.G.S., F.R.G.S., Director of the Geological Survey of Canada. Montreal, Canada.
1868. ‡Login, Thomas, C.E., F.R.S.E. India.
1862. ‡Long, Andrew, M.A. King's College, Cambridge.
1872. ‡Long, Jeremiah. 50 Marine Parade, Brighton.
1871. ‡Long, John Jex. 12 Whitevale, Glasgow.
1851. ‡Long, William, F.G.S. Hurts Hall, Saxmundham, Suffolk.
1866. §Longdon, Frederick. Luamdur, near Derby.
1857. ‡Longfield, Rev. George, D.D. Trinity College, Dublin.
LONGFIELD, MOUNTIFORT, LL.D., M.R.I.A., Regius Professor of Feudal and English Law in the University of Dublin. 47 Fitzwilliam-square, Dublin.
1861. *Longman, William, F.G.S. 36 Hyde-park-square, London, W.
1859. ‡Longmuir, Rev. John, M.A., LL.D. 14 Silver-street, Aberdeen.
Longridge, William S. Oakhurst, Ambergate, Derbyshire.
1871. §Longstaff, George Dixon, M.D., F.C.S. Southfields, Wandsworth, S.W.; and 9 Upper Thames-street, London, E.C.
1872. *Longstaff, Llewellyn Wood, F.R.G.S. Summergangs, Hull.
1861. *Lord, Edward. Adamroyd, Todmorden.
1863. ‡Losh, W. S. Wreay Syke, Carlisle.
1867. *Low, James F. Monifieth, by Dundee.

Year of Election.

1863. *Lowe, Lieut.-Colonel Arthur S. H., F.R.A.S. 76 Lancaster-gate, London, W.
1861. *LOWE, EDWARD JOSEPH, F.R.S., F.R.A.S., F.L.S., F.G.S., F.M.S. Highfield House Observatory, near Nottingham.
1870. ‡Lowe, G. C. 67 Cecil-street, Greenheys, Manchester.
1868. ‡Lowe, John, M.D. King's Lynn.
1850. ‡Lowe, William Henry, M.D., F.R.S.E. Balgreen, Slateford, Edinburgh.
1853. *LUBBOCK, Sir JOHN, Bart., M.P., F.R.S., F.L.S., F.G.S. High Elms, Farnborough, Kent.
1870. ‡Lubbock, Montague. High Elms, Farnborough, Kent.
1849. *Luckcock, Howard. Oak-hill, Edgbaston, Birmingham.
1867. *Luis, John Henry. Cidhmore, Dundee.
1873. ‡Lumley, J. Hope Villa, Thornbury, near Bradford, Yorkshire.
1866. *Lund, Charles. 1 Blenheim-road, Bradford, Yorkshire.
1873. ‡Lund, Joseph. St. George's-place, Bradford, Yorkshire.
1873. ‡Lund, Joseph. St. George's-place, Bradford, Yorkshire.
1850. *Lundie, Cornelius. Tweed Lodge, Charles-street, Cardiff.
1853. ‡Lunn, William Joseph, M.D. 23 Charlotte-street, Hull.
1858. *Lupton, Arthur. Headingley, near Leeds.
1864. *Lupton, Darnton, jun. The Harehills, near Leeds.
1874. *Lupton, Sydney. The Harehills, near Leeds.
1864. *Lutley, John. Brockhampton Park, Worcester.
1866. ‡LYCETT, Sir FRANCIS. 18 Highbury-grove, London, N.
1871. ‡Lyell, Leonard. 42 Regent's Park-road, London, N.W.
1874. §Lynam, James, C.E. Ballinasloe, Ireland.
1857. ‡Lyons, Robert D., F.R.C.P.I. 8 Merrion-square West, Dublin.
1862. *Lyte, F. Maxwell, F.C.S. 6 Cité de Retiro, Faubourg St. Honoré, Paris.
1849. ‡LYTTELTON, The Right Hon. Lord, D.C.L., F.R.S. 12 Stratton-street, London, W.

1852. ‡MacAdam, Robert. 18 College-square East, Belfast.
1854. *MACADAM, STEVENSON, Ph.D., F.R.S.E., F.C.S., Lecturer on Chemistry. Surgeons' Hall, Edinburgh; and Brighton House, Portobello, by Edinburgh.
1868. ‡MACALISTER, ALEXANDER, M.D., Professor of Zoology in the University of Dublin. 13 Adelaide-road, Dublin.
1868. ‡M'Allan, W. A. Norwich.
1866. *M'Arthur, A., M.P. Raleigh Hall, Brixton Rise, London, S.W.
1840. Macaulay, James A. M., M.D. 22 Cambridge-road, Kilburn, London, N.W.
1871. ‡M'Bain, James, M.D., R.N. Logie Villa, York-road, Trinity, Edinburgh.
*MacBrayne, Robert. Househill Hamlet, Glasgow.
1866. ‡M'CALLAN, Rev. J. F., M.A. Basford, near Nottingham.
1855. ‡*M'Callum, Archibald K., M.A.*
1863. ‡M'Calmont, Robert. Gatton Park, Reigate.
1855. ‡M'Cann, Rev. James, D.D., F.R.S.L., F.G.S. 18 Shaftesbury-terrace, Glasgow.
1840. M'Clelland, James, F.S.S. 32 Pembridge-square, London, W.
1868. ‡M'CLINTOCK, Rear-Admiral Sir FRANCIS L., R.N., F.R.S., F.R.G.S. United Service Club, Pall Mall, London, S.W.
1872. *M'Clure, J. H. Strutt-street, Manchester.
1874. §M'Clure, Sir Thomas, Bart. Belmont, Belfast.
*M'Connel, James. Moore-place, Esher, Surrey.
1859. *M'Connell, David C., F.G.S. 44 Manor-place, Edinburgh.

Year of Election.

1858. ‡M'Connell, J. E. Woodlands, Great Missenden.
1871. ‡M'Donald, William. Yokohama, Japan. (Care of R. K. Knevitt, Esq., Sun-court, Cornhill, E.C.)
MacDonnell, Hercules H. G. 2 Kildare-place, Dublin.
*McEwan, John. 9 Melville-terrace, Stirling, N.B.
1859. ‡Macfarlane, Alexander. 73 Bon Accord-street, Aberdeen.
1871. §M'Farlane, Donald. The College Laboratory, Glasgow.
1855. *M'Farlane, Walter. 231 St. Vincent-street, Glasgow.
1854. *MACFIE, ROBERT ANDREW. 13 Victoria-street, Westminster, S.W.
1867. *M'Gavin, Robert. Ballumbie, Dundee.
1855. ‡MacGeorge, Andrew, jun. 21 St. Vincent-place, Glasgow.
1872. ‡McGeorge, Mungo. Nithodale, Laurie-park, Sydenham, S.E.
1873. ‡McGowen, William Thomas. Oak-avenue, Oak Mount, Bradford, Yorkshire.
1855. ‡M'Gregor, Alexander Bennett. 19 Woodside-crescent, Glasgow.
1855. ‡MacGregor, James Watt. Wallace-grove, Glasgow.
1859. ‡M'Hardy, David. 54 Netherkinkgate, Aberdeen.
1859. ‡Macintosh, John. Middlefield House, Woodside, Aberdeen.
1874. §MacIlwaine, Rev. William, D.D. Ulsterville, Belfast.
1867. *McINTOSH, W. C., M.D., F.L.S. Murthly, Perthshire.
1854. *MacIver, Charles. 8 Water-street, Liverpool.
1871. ‡Mackay, Rev. A., LL.D., F.R.G.S. 1 Hatton-place, Grange, Edinburgh.
1873. ‡McKendrick, John G., M.D. 29 Castle-terrace, Edinburgh.
1855. ‡M'Kenzie, Alexander. 89 Buchanan-street, Glasgow.
*Mackenzie, James. Glentore, by Glasgow.
1865. ‡Mackeson, Henry B., F.G.S. Hyde, Kent.
1872. *Mackey, J. A. 24 Buckingham-place, Brighton.
1867. §MACKIE, SAMUEL JOSEPH, F.G.S. 84 Kensington Park-road, London, W.
*Mackinlay, David. Great Western-terrace, Hillhead, Glasgow.
1865. ‡Mackintosh, Daniel, F.G.S. Chichester.
1850. ‡Macknight, Alexander. 12 London-street, Edinburgh.
1867. §Mackson, H. G. 25 Cliff-road, Woodhouse, Leeds.
1872. *MACLACHLAN, ROBERT, F.L.S. 39 Limes-grove, Lewisham, S.E.
1873. ‡McLandsborough, John, C.E., F.R.A.S., F.G.S. Shipley, near Bradford, Yorkshire.
1860. ‡Maclaren, Archibald. Summertown, Oxfordshire.
1864. §MACLAREN, DUNCAN, M.P. Newington House, Edinburgh.
1873. ‡MacLaren, Walter S. B. Newington House, Edinburgh.
1859. ‡MACLEAR, Sir THOMAS, F.R.S., F.R.G.S., F.R.A.S., late Astronomer Royal at the Cape of Good Hope. Cape Town, South Africa.
1862. ‡Macleod, Henry Dunning. 17 Gloucester-terrace, Campden-hill-road, London, W.
1868. §M'LEOD, HERBERT, F.C.S. Indian Civil Engineering College, Cooper's Hill, Egham.
1861. *Maclure, John William. 2 Bond-street, Manchester.
1862. ‡Macmillan, Alexander. Streatham-lane, Upper Tooting, Surrey.
1874. §MacMordie, Hans, M.A. 8 Donegall-street, Belfast.
1871. ‡M'Nab, William Ramsay, M.D. Royal Agricultural College, Cirencester.
1870. ‡Macnaught, John, M.D. 74 Huskisson-street, Liverpool.
1867. §M'Neill, John. Balhousie House, Perth.
MACNEILL, The Right Hon. Sir JOHN, G.C.B., F.R.S.E., F.R.G.S. Granton House, Edinburgh.
MACNEILL, Sir JOHN, LL.D., F.R.S., M.R.I.A. 17 The Grove, South Kensington, London, S.W.

Year of Election.

1859. ‡Macpherson, Rev. W. Kilmuir Easter, Scotland.
1852. *Macrory, Adam John. Duncairn, Belfast.
*Macrory, Edmund, M.A. 40 Leinster-square, Bayswater, London, W.
1855. ‡M'Tyre, William, M.D. Maybole, Ayrshire.
1855. ‡Macvicar, Rev. John Gibson, D.D., LL.D. Moffat, N.B.
1868. ‡Magnay, F. A. Drayton, near Norwich.
Magor, J. B. Redruth, Cornwall.
1869. §Main, Rev. R., F.R.S., F.R.A.S., Director of the Radcliffe Observatory, Oxford.
1869. ‡Main, Robert. Admiralty, Somerset House, W.C.
1866. §Major, Richard Henry, F.S.A., F.R.G.S. British Museum, London, W.C.
*Malahide, The Right Hon. Lord Talbot de, M.A., F.R.S., F.G.S., F.S.A. Malahide Castle, Co. Dublin.
*Malcolm, Frederick. Mordon College, Blackheath, London, S.E.
1870. *Malcolm, Sir James, Bart. The Priory, St. Michael's Hamlet, Aigburth, Liverpool.
1874. §Malcolmson, A. B. Friends' Institute, 12 Bishopsgate-street Without, London, E.C.
1863. ‡Maling, C. T. Lovaine-crescent, Newcastle-on-Tyne.
1857. ‡Mallet, Dr. John William, F.C.S., Professor of Chemistry in the University of Virginia, U. S.
*Mallet, Robert, Ph.D., F.R.S., F.G.S., M.R.I.A. The Grove, Clapham-road, Clapham; and 7 Westminster-chambers, Victoria-street, London, S.W.
1846. ‡Manby, Charles, F.R.S., F.G.S. 60 Westbourne-terrace, Hyde Park, London, W.
1870. ‡Manifold, W. H. 45 Rodney-street, Liverpool.
1866. §Mann, Robert James, M.D., F.R.A.S. 5 Kingsdown-villas, Wandsworth Common, S.W.
Manning, The Right Rev. H.
1866. ‡Manning, John. Waverley-street, Nottingham.
1864. ‡Mansel, J. C. Long Thorns, Blandford.
1865. ‡March, J. F. Fairfield House, Warrington.
1870. ‡Marcoartu, Senor Don Arturo de. Madrid.
1864. ‡Markham, Clements R., C.B., F.R.S., F.L.S., F.R.G.S., F.S.A. 21 Eccleston-square, Pimlico, London, S.W.
1863. ‡Marley, John. Mining Office, Darlington.
*Marling, Samuel S., M.P. Stanley Park, Stroud, Gloucestershire.
1871. §Marreco, A. Friere-. College of Physical Science, Newcastle-on-Tyne.
Marriott, John.
1857. §Marriott, William, F.C.S. Grafton-street, Huddersfield.
1842. Marsden, Richard. Norfolk-street, Manchester.
1870. ‡Marsh, John. Rann Lea, Rainhill, Liverpool.
1856. ‡*Marsh, M. H.*
1864. ‡Marsh, Thomas Edward Miller. 37 Grosvenor-place, Bath.
1852. ‡Marshall, James D. Holywood, Belfast.
1858. ‡Marshall, Reginald Dykes. Adel, near Leeds.
1849. *Marshall, William P. 6 Portland-road, Edgbaston, Birmingham.
1865. §Marten, Edward Bindon. Pedmore, near Stourbridge.
1848. ‡Martin, Henry D. 4 Imperial-circus, Cheltenham.
1871. ‡Martin, Rev. Hugh, M.A. Greenhill-cottage, Lasswade by Edinburgh.
1870. ‡Martin, Robert, M.D. 120 Upper Brook-street, Manchester.
1836. Martin, Studley. 177 Bedford-street South, Liverpool.
1867. *Martin, William, jun. 3 Airlie-place, Dundee.

Year of Election.

*Martindale, Nicholas. Berryarbor, Ilfracombe.
*Martineau, Rev. James. 5 Gordon-street, Gordon-square, London, W.C.
1865. ‡Martineau, R. F. Highfield-road, Edgbaston, Birmingham.
1865. ‡Martineau, Thomas. 7 Cannon-street, Birmingham.
1847. ‡MASKELYNE, NEVIL STORY, M.A., F.R.S., F.G.S., Keeper of the Mineralogical Department, British Museum; and Professor of Mineralogy in the University of Oxford. 112 Gloucester-terrace, Hyde-park-gardens, London, W.
1861. *Mason, Hugh. Groby Lodge, Ashton-under-Lyne.
1868. ‡Mason, James Wood, F.G.S. The Indian Museum, Calcutta. (Care of Messrs. Henry S. King & Co., 65 Cornhill, London, E.C.)
Massey, Hugh, Lord. Hermitage, Castleconnel, Co. Limerick.
1870. ‡Massey, Thomas. 5 Gray's-Inn-square, London, W.C.
1870. ‡Massy, Frederick. 50 Grove-street, Liverpool.
1865. *Mathews, G. S. Portland-road, Edgbaston, Birmingham.
1861. *MATHEWS, WILLIAM, M.A., F.G.S. 49 Harborne-road, Birmingham.
1859. ‡Matthew, Alexander C. 3 Canal-terrace, Aberdeen.
1865. ‡Matthews, C. E. Waterloo-street, Birmingham.
1858. ‡Matthews, F. C. Mandre Works, Driffield, Yorkshire.
1860. §Matthews, Rev. Richard Brown. Shalford Vicarage, near Guildford.
1863. ‡Maughan, Rev. W. Benwell Parsonage, Newcastle-on-Tyne.
1855. ‡Maule, Rev. Thomas, M.A. Partick, near Glasgow.
1865. *MAW, GEORGE, F.L.S., F.G.S., F.S.A. Benthall Hall, Broseley, Shropshire.
1864. *Maxwell, Francis. Dunragit, Wigtownshire.
*MAXWELL, JAMES CLERK, M.A., LL.D., F.R.S.L. & E., Professor of Experimental Physics in the University of Cambridge. Glenlair, Dalbeattie, N.B.; and 11 Scroope-terrace, Cambridge.
*Maxwell, Robert Perceval. Groomsport House, Belfast.
1865. *May, Walter. Elmley Lodge, Harborne, Birmingham.
1868. §Mayall, J. E., F.C.S. Stork's-nest, Lancing, Sussex.
1863. §Mease, George D. Bylton Villa, South Shields.
1863. ‡Mease, Solomon. Cleveland House, North Shields.
‡Meath, Samuel Butcher, D.D., Lord Bishop of. Ardbraccan, Co. Meath.
1871. ‡Meikie, James, F.S.S. 6 St. Andrew's-square, Edinburgh.
1867. ‡MELDRUM, CHARLES. Mauritius.
1866. ‡Mello, Rev. J. M. St. Thomas's Rectory, Brampton, Chesterfield.
1854. ‡Melly, Charles Pierre. 11 Rumford-street, Liverpool.
1847. ‡Melville, Professor Alexander Gordon, M.D. Queen's College, Galway.
1863. ‡Melvin, Alexander. 42 Buccleuch-place, Edinburgh.
1862. §MENNELL, HENRY J. St. Dunstan's-buildings, Great Tower-street, London, E.C.
1868. §MERRIFIELD, CHARLES W., F.R.S., Principal of the Royal School of Naval Architecture, Superintendent of the Naval Museum at South Kensington, Hon. Sec. I.N.A. 20 Pembroke-gardens, Kensington, London, W.
1872. ‡Merryweather, Richard M. Clapham House, Clapham Common, London, S.W.
1871. ‡Merson, John. Northumberland County Asylum, Morpeth.
1872. *Messent, John. 429 Strand, London, W.C.
1863. ‡Messent, P. T. 4 Northumberland-terrace, Tynemouth.

Year of Election.

1869. §MIALL, LOUIS C. Philosophical Hall, Leeds
1847. *Michell, Rev. Richard, D.D., Principal of Magdalen Hall, Oxford.
1865. ‡Michie, Alexander. 26 Austin Friars, London, E.C.
1865. ‡Middlemore, William. Edgbaston, Birmingham.
1866. ‡Midgley, John. Colne, Lancashire.
1867. ‡Midgley, Robert. Colne, Lancashire.
1859. ‡Millar, John. Lisburn, Ireland.
1863. §Millar, John, M.D., F.L.S., F.G.S. Bethnal House, Cambridge-road, London, E.
Millar, Thomas, M.A., LL.D., F.R.S.E. Perth.
1865. ‡Miller, Rev. Canon J. C., D.D. The Vicarage, Greenwich, London, S.E.
1861. *Miller, Robert. Broomfield House, Reddish, near Manchester.
MILLER, WILLIAM HALLOWS, M.A., LL.D., F.R.S., F.G.S., Professor of Mineralogy in the University of Cambridge. 7 Scroope-terrace, Cambridge.
1868. *Milligan, Joseph, F.L.S., F.G.S., F.R.A.S., F.R.G.S. 6 Craven-street, Strand, London, W.C.
1842. Milligan, Robert. Acacia in Rawdon, Leeds.
1868. §MILLS, EDMUND J., D.Sc., F.R.S., F.C.S., Assistant Chemical Examiner in the University of London. 12 Pemberton-terrace, St. John's-park, London, N.
*Mills, John Robert. 11 Bootham, York.
Milne, Admiral Sir Alexander, G.C.B., F.R.S.E. 65 Rutland-gate, London, S.W.
1867. ‡Milne, James. Murie House, Errol, by Dundee.
1867. *MILNE-HOME, DAVID, M.A., F.R.S.E., F.G.S. 10 York-place, Edinburgh.
1854. *Milner, William. 50 Bentley-road, Liverpool.
1864. *MILTON, The Right Hon. Lord, F.R.G.S. 17 Grosvenor-street, London, W.; and Wentworth, Yorkshire.
1865. ‡Minton, Samuel, F.G.S. Oakham House, near Dudley.
1855. ‡Mirrlees, James Buchanan. 45 Scotland-street, Glasgow.
1859. ‡Mitchell, Alexander, M.D. Old Rain, Aberdeen.
1863. ‡Mitchell, C. Walker. Newcastle-on-Tyne.
1873. ‡Mitchell, Henry. Parkfield House, Bradford, Yorkshire.
1870. §Mitchell, John. York House, Clitheroe, Lancashire.
1868. §Mitchell, John, jun. Pole Park House, Dundee.
1862. *MITCHELL, WILLIAM STEPHEN, LL.B., F.L.S., F.G.S. Caius College, Cambridge.
1855. *Moffat, John, C.E. Ardrossan, Scotland.
1854. §MOFFAT, THOMAS, M.D., F.G.S., F.R.A.S., F.M.S. Hawarden, Chester.
1864. ‡Mogg, John Rees. High Littleton House, near Bristol.
1866. §MOGGRIDGE, MATTHEW, F.G.S. Woodfield, Monmouthshire.
1855. §Moir, James. 174 Gallogate, Glasgow.
1861. ‡Molesworth, Rev. W. N., M.A. Spotland, Rochdale.
Mollan, John, M.D. 8 Fitzwilliam-square North, Dublin.
1852. ‡Molony, William, LL.D. Carrickfergus.
1865. §MOLYNEUX, WILLIAM, F.G.S. Branston Cottage, Burton-upon-Trent.
1860. ‡Monk, Rev. William, M.A., F.R.A.S. Wymington Rectory, Higham Ferrers, Northamptonshire.
1853. ‡Monroe, Henry, M.D. 10 North-street, Sculcoates, Hull.
1872. §Montgomery, R. Mortimer. 3 Porchester-place, Edgeware-road, London, W.
1872. ‡Moon, W., LL.D. 104 Queen's-road, Brighton.

Year of Election.

1859. ‡Moore, Charles, F.G.S. 6 Cambridge-terrace, Bath.
1874. §Moore, David, F.L.S. Glasnevin, Dublin.
1857. ‡Moore, Rev. John, D.D. Clontarf, Dublin.
Moore, John. 2 Meridian-place, Clifton, Bristol.
*Moore, John Carrick, M.A., F.R.S., F.G.S. 113 Eaton-square, London, S.W.; and Corswall, Wigtonshire.
1866. *Moore, Thomas, F.L.S. Botanic Gardens, Chelsea, London, S.W.
1854. ‡Moore, Thomas John, Cor. M.Z.S. Free Public Museum, Liverpool.
1857. *Moore, Rev. William Prior. The Royal School, Cavan, Ireland.
1871. ‡More, Alexander, F.L.S., M.R.I.A. 3 Botanic View, Glasnevin, Dublin.
1873. §Morgan, Edward Delmar. 19 Queen's-gardens, London, W.
1868. ‡Morgan, Thomas H. Oakhurst, Hastings.
1833. Morgan, William, D.C.L. Oxon. Uckfield, Sussex.
1867. ‡Morison, William R. Dundee.
1863. ‡Morley, Samuel, M.P. 18 Wood-street, Cheapside, London, E.C.
1865. *Morrieson, Colonel Robert. Oriental Club, Hanover-square, London, W.
*Morris, Rev. Francis Orpen, B.A. Nunburnholme Rectory, Hayton, York.
Morris, Samuel, M.R.D.S. Fortview, Clontarf, near Dublin.
1861. ‡*Morris, William.*
1871. *Morrison, James Darsie. 27 Grange-road, Edinburgh.
1874. §Morrison, J. G., C.E. 5 Victoria-street, Westminster, S.W.
1863. ‡Morrow, R. J. Bentick-villas, Newcastle-on-Tyne.
1865. §Mortimer, J. R. St. John's-villas, Driffield.
1869. ‡Mortimer, William. Bedford-circus, Exeter.
1857. §Morton, George H., F.G.S. 21 West Derby-street, Liverpool.
1858. *Morton, Henry Joseph. Garforth House, West Garforth, near Leeds.
1871. ‡Morton, Hugh. Belvedere House, Trinity, Edinburgh.
1868. ‡Moseley, H. N. Olveston, Bristol.
1857. ‡Moses, Marcus. 4 Westmoreland-street, Dublin.
Mosley, Sir Oswald, Bart., D.C.L. Rolleston Hall, Burton-upon-Trent, Staffordshire.
Moss, John. Otterspool, near Liverpool.
1870. ‡Moss, John Miles, M.A. 2 Esplanade, Waterloo, Liverpool.
1873. *Mosse, George S. 12 Eldon-road, Kensington, London, W.
1864. *Mosse, J. R. Public Works' Department, Ceylon. (Care of Messrs. H. S. King & Co., 65 Cornhill, London, E.C.)
1873. §Mossman, William. Woodhall, Calverley, Leeds.
1869. §Mott, Albert J. Claremont House, Seaforth, Liverpool.
1865. §Mott, Charles Grey. The Park, Birkenhead.
1866. §Mott, Frederick T., F.R.G.S. 1 De Montfort-street, Leicester.
1872. §Mott, Miss Minnie. 1 De Montfort-street, Leicester.
1862. *Mouat, Frederick John, M.D., late Inspector-General of Prisons, Bengal. 12 Durham-villas, Campden-hill, London, W.
1856. ‡Mould, Rev. J. G., B.D. Fulmodeston Rectory, Dereham, Norfolk.
1863. ‡Mounsey, Edward. Sunderland.
Mounsey, John. Sunderland.
1861. *Mountcastle, William Robert. Ellenbrook, near Manchester.
Mowbray, James. Combus, Clackmannan, Scotland.
1850. ‡Mowbray, John T. 15 Albany-street, Edinburgh.
1874. §Muir, M. M. Pattison. Anderson's University, Glasgow.
1871. ‡*Muir, W. Hamilton.*

Year of Election.

1872. ‡Muirhead, Alexander, D.Sc., F.C.S. 159 Camden-road, London, N.
1871. *Muirhead, Henry, M.D. Bushy-hill, Cambuslang, Lanarkshire.
1857. ‡*Mullins, M. Bernard, M.A., C.E.*
Munby, Arthur Joseph. 6 Fig-tree-court, Temple, London, E.C.
1866. ‡MUNDELLA, A. J., M.P., F.R.G.S. The Park, Nottingham.
1864. *MUNRO, Major-General WILLIAM, C.B., F.L.S. United Service Club, Pall Mall, London, S.W.; and Mapperton Lodge, Farnborough, Hants.
1872. *Munster, H. Selwood Lodge, Brighton.
1872. *Munster, William Felix. Selwood Lodge, Brighton.
1864. §MURCH, JEROM. Cranwells, Bath.
*Murchison, John Henry. Surbiton-hill, Kingston, S.W.
1864. *Murchison, K. R. Ashurst Lodge, East Grinstead.
1855. ‡Murdock, James B. Hamilton-place, Langside, Glasgow.
1852. ‡Murney, Henry, M.D. 10 Chichester-street, Belfast.
1852. §Murphy, Joseph John. Old Forge, Dunmurry, Co. Antrim.
1869. §Murray, Adam. 4 Westbourne-crescent, Hyde Park, London, W.
1850. ‡MURRAY, ANDREW, F.L.S. 67 Bedford-gardens, Kensington, London, W.
1871. ‡Murray, Captain, R.N. Murrathwaite, Ecclefachan, Scotland.
1871. §Murray, Dr. Ivor, F.R.S.E. The Knowle, Brenchley, Staplehurst, Kent.
Murray, John, F.G.S., F.R.G.S. 50 Albemarle-street, London, W.; and Newsted, Wimbledon, Surrey.
1871. §Murray, John. 3 Clarendon-crescent, Edinburgh.
1859. ‡Murray, John, M.D. Forres, Scotland.
*Murray, John, C.E. Downlands, Sutton, Surrey.
‡Murray, Rev. John. Morton, near Thornhill, Dumfriesshire.
1872. ‡Murray, J. Jardine. 99 Montpellier-road, Brighton.
1863. ‡Murray, William. 34 Clayton-street, Newcastle-on-Tyne.
1859. *Murton, James. Highfield, Silverdale, Carnforth, Lancaster.
*Musgrave, The Venerable Charles, D.D., Archdeacon of Craven. Halifax.
1874. §Musgrave, James, J.P. Drumglass House, Belfast.
1861. ‡Musgrove, John, jun. Bolton.
1870. *Muspratt, Edward Knowles. Seaforth Hall, near Liverpool.
1865. ‡Myers, Rev. E., F.G.S. 3 Waterloo-road, Wolverhampton.
1859. §MYLNE, ROBERT WILLIAM, F.R.S., F.G.S., F.S.A. 21 Whitehall-place, London, S.W.

1850. ‡Nachot, H. W., Ph.D. 73 Queen-street, Edinburgh.
1842. Nadin, Joseph. Manchester.
1855. *NAPIER, JAMES R., F.R.S. 22 Blythwood-square, Glasgow.
*Napier, Captain Johnstone, C.E. Tavistock House, Salisbury.
1839. *NAPIER, The Right Hon. Sir JOSEPH, Bart. 4 Merrion-square South, Dublin.
1855. ‡Napier, Robert. West Chandon, Gareloch, Glasgow.
Napper, James William L. Loughcrew, Oldcastle., Co. Meath.
1872. §Nares, Capt. G. S., R.N., F.R.G.S. Messrs. Grant's Bank, Portsmouth.
1866. ‡Nash, Davyd W., F.S.A., F.L.S. 10 Imperial-square, Cheltenham.
1850. *NASMYTH, JAMES. Penshurst, Tunbridge.
1864. ‡Natal, William Colenso, Lord Bishop of. Natal.
1860. ‡Neate, Charles, M.A. Oriel College, Oxford.
1867. §NEAVES, The Right Hon. Lord. 7 Charlotte-square, Edinburgh.
1873. ‡Neill, Alexander Renton. Fieldhead House, Bradford, Yorkshire.
1873. ‡Neill, Archibald. Fieldhead House, Bradford, Yorkshire.
1853. ‡*Neill, William, Governor of Hull Jail.*

Year of Election.

1855. ‡Neilson, Walter. 172 West George-street, Glasgow.
1865. ‡Neilson, W. Montgomerie. Glasgow.
Ness, John. Helmsley, near York.
1868. ‡Nevill, Rev. H. R. The Close, Norwich.
1866. *Nevill, Rev. Samuel Tarratt, D.D., F.L.S., Bishop of Dunedin, New Zealand.
1857. ‡Neville, John, C.E., M.R.I.A. Roden-place, Dundalk, Ireland.
1852. ‡Neville, Parke, C.E. Town Hall, Dublin.
1869. ‡Nevins, John Birkbeck, M.D. 3 Abercromby-square, Liverpool.
1842. New, Herbert. Evesham, Worcestershire.
Newall, Henry. Hare-hill, Littleborough, Lancashire.
*Newall, Robert Stirling. Ferndene, Gateshead-upon-Tyne.
1866. *Newdigate, Albert L. 2 The Pavement, Clapham Common, London, S.W.
1842. *NEWMAN, Professor FRANCIS WILLIAM. 13 Arundel-crescent, Weston-super-Mare.
1863. *NEWMARCH, WILLIAM, F.R.S. Beech Holme, Clapham Common, London, S.W.
1866. **Newmarch, William Thomas.*
1860. *NEWTON, ALFRED, M.A., F.R.S., F.L.S., Professor of Zoology and Comparative Anatomy in the University of Cambridge. Magdalen College, Cambridge.
1872. ‡Newton, Rev. J. 125 Eastern-road, Brighton.
1865. ‡Newton, Thomas Henry Goodwin. Clopton House, near Stratford-on-Avon.
1867. ‡Nicholl, Dean of Guild. Dundee.
1874. §Nicholls, N. F. King's-square, Bridgewater, Somerset.
1866. §NICHOLSON, Sir CHARLES, Bart., D.C.L., LL.D., M.D., F.G.S., F.R.G.S. 26 Devonshire-place, Portland-place, London, W.
1838. *Nicholson, Cornelius, F.G.S., F.S.A. Wellfield, Muswell-hill, London, N.
1861. *Nicholson, Edward. 88 Mosley-street, Manchester.
1871. §Nicholson, E. Chambers. Herne-hill, London, S.E.
1867. ‡NICHOLSON, HENRY ALLEYNE, M.D., D.Sc., F.G.S., Professor of Natural History in the University of St. Andrews, N.B.
1850. ‡NICOL, JAMES, F.R.S.E., F.G.S., Professor of Natural History in Marischal College, Aberdeen.
1867. ‡Nimmo, Dr. Matthew, L.R.C.S.E. Nethergate, Dundee.
Niven, Ninian. Clonturk Lodge, Drumcondra, Dublin.
‡Nixon, Randal, C. J., M.A. Green Island, Belfast.
1864. ‡NOAD, HENRY M., Ph.D., F.R.S., F.C.S. 72 Hereford-road, Bayswater, London, W.
1863. *NOBLE, Captain, F.R.S. Elswick Works, Newcastle-on-Tyne.
1870. ‡Nolan, Joseph. 14 Hume-street, Dublin.
1860. *Nolloth, Rear-Admiral Matthew S., R.N., F.R.G.S. United Service Club, S.W.; and 13 North-terrace, Camberwell, London, S.E.
1859. ‡Norfolk, Richard. Messrs. W. Rutherford and Co., 14 Canada Dock, Liverpool.
1868. ‡Norgate, William. Newmarket-road, Norwich.
1863. §NORMAN, Rev. ALFRED MERLE, M.A. Burnmoor Rectory, Fence House, Co. Durham.
Norreys, Sir Denham Jephson, Bart. Mallow Castle, Co. Cork.
1865. ‡NORRIS, RICHARD, M.D. 2 Walsall-road, Birchfield, Birmingham.
1872. §Norris, Thomas George. Gorphwysfa, Llanrwst, North Wales.
1866. ‡North, Thomas. Cinder-hill, Nottingham.
NORTHAMPTON, The Right Hon. CHARLES DOUGLAS, Marquis of. 145 Piccadilly, London, W.; and Castle Ashby, Northamptonshire.

Year of Election.

1869. ‡NORTHCOTE, The Right Hon. Sir STAFFORD H., Bart., C.B., M.P., F.R.S. Pynes, Exeter; and 86 Harley-street, London, W.
*NORTHWICK, The Right Hon. Lord, M.A. 7 Park-street, Grosvenor-square, London, W.
1868. ‡Norwich, The Hon. and Right Rev. J. T. Pelham, D.D., Lord Bishop of. Norwich.
1861. ‡Noton, Thomas. Priory House, Oldham.
Nowell, John. Farnley Wood, near Huddersfield.

O'Brien, Baron Lucius. Dromoland, Newmarket-on-Fergus, Ireland.
O'Callaghan, George. Tallas, Co. Clare.
Odgers, Rev. William James. Savile House, Weston-road, Bath.
1858. *ODLING, WILLIAM, M.B., F.R.S., F.C.S., Waynflete Professor of Chemistry in the University of Oxford. The Museum, Oxford.
1857. ‡O'Donnavan, William John. Portarlington, Ireland.
1870. ‡O'Donnell, J. O., M.D. 34 Rodney-street, Liverpool.
1866. ‡Ogden, James. Woodhouse, Loughborough.
1859. ‡Ogilvie, C. W. Norman. Baldovan House, Dundee.
*OGILVIE, GEORGE, M.D., Professor of the Institutes of Medicine in Marischal College, Aberdeen. 29 Union-place, Aberdeen.
1874. §Ogilvie, Thomas Robertson. 19 Brisbane-street, Greenock, N.B.
1863. ‡Ogilvy, G. R. Inverquharity, N.B.
1863. ‡OGILVY, Sir JOHN, Bart. Inverquharity, N.B.
*Ogle, William, M.D., M.A. 98 Friar-gate, Derby.
1859. ‡Ogston, Francis, M.D. 18 Adelphi-court, Aberdeen.
1837. ‡O'Hagan, John. 22 Upper Fitzwilliam-street, Dublin.
1874. §O'HAGAN, The Right Hon. Lord. Dublin.
1862. ‡O'KELLY, JOSEPH, M.A. 51 Stephen's-green, Dublin.
1857. ‡O'Kelly, Matthias J. Dalkey, Ireland.
1853. §OLDHAM, JAMES, C.E. Cottingham, near Hull.
1857. *OLDHAM, THOMAS, M.A., LL.D., F.R.S., F.G.S., M.R.I.A., Director of the Geological Survey of India. 1 Hastings-street, Calcutta.
1860. ‡O'Leary, Professor Purcell, M.A. Queenstown.
1863. ‡Oliver, Daniel, F.R.S., Professor of Botany in University College, London. Royal Gardens, Kew, W.
1874. §O'Meara, Rev. Eugene. Newcastle Rectory, Hazlehatch, Ireland.
*OMMANNEY, Vice-Admiral ERASMUS, C.B., F.R.S., F.R.A.S., F.R.G.S. 6 Talbot-square, Hyde Park, London, W.; and United Service Club, Pall Mall, London, S.W.
1872. ‡Onslow, D. Robert. New University Club, St. James's, London, S.W.
1867. ‡Orchar, James G. 9 William-street, Forebank, Dundee.
1842. ORMEROD, GEORGE WAREING, M.A., F.G.S. Brookbank, Teignmouth.
1861. ‡Ormerod, Henry Mere. Clarence-street, Manchester; and 11 Woodland-terrace, Cheetham-hill, Manchester.
1858. ‡Ormerod, T. T. Brighouse, near Halifax.
1835. ORPEN, JOHN H., LL.D., M.R.I.A. 58 Stephen's-green, Dublin.
1873. ‡Osborn, George. 47 Kingcross-street, Halifax.
1865. ‡Osborne, E. C. Carpenter-road, Edgbaston, Birmingham.
*OSLER, A. FOLLETT, F.R.S. South Bank, Edgbaston, Birmingham.
1865. *Osler, Henry F. 50 Carpenter-road, Edgbaston, Birmingham.
1869. *Osler, Sidney F. South Bank, Edgbaston, Birmingham.
1854. ‡Outram, Thomas. Greetland, near Halifax.
OVERSTONE, SAMUEL JONES LLOYD, Lord, F.G.S. 2 Carlton-gardens, London, S.W.; and Wickham Park, Bromley.
1870. ‡Owen, Harold. The Brook Villa, Liverpool.

Year of Election.

1857. ‡Owen, James H. Park House, Sandymount, Co. Dublin.
OWEN, RICHARD, C.B., M.D., D.C.L., LL.D., F.R.S., F.L.S., F.G.S., Hon. M.R.S.E., Director of the Natural-History Department, British Museum. Sheen Lodge, Mortlake, Surrey, S.W.
1863. *Ower, Charles, C.E. 11 Craigie-terrace, Dundee.

1859. ‡PAGE, DAVID, LL.D., F.R.S.E., F.G.S. College of Physical Science, Newcastle-upon-Tyne.
1863. ‡Paget, Charles. Ruddington Grange, near Nottingham.
1872. *Paget, Joseph. Stuffynwood Hall, Mansfield, Nottingham.
1870. *Palgrave, R. H. Inglis. 11 Britannia-terrace, Great Yarmouth.
1873. ‡Palmer, George. The Acacias, Reading, Berks.
1866. §Palmer, H. 76 Goldsmith-street, Nottingham.
1866. §Palmer, William. Iron Foundry, Canal-street, Nottingham.
1872. *Palmer, W. R. Phœnix Lodge, Brixton, London, S.W.
Palmes, Rev. William Lindsay, M.A. The Vicarage, Hornsea, Hull.
1857. *Parker, Alexander, M.R.I.A. 59 William-street, Dublin.
1863. ‡Parker, Henry. Low Elswick, Newcastle-on-Tyne.
1863. ‡Parker, Rev. Henry. Idlerton Rectory, Low Elswick, Newcastle-on-Tyne.
1874. §Parker, Henry R., LL.D. Methodist College, Belfast.
Parker, Joseph, F.G.S. Upton Chaney, Bitton, near Bristol.
Parker, Richard. Dunscombe, Cork.
1865. *Parker, Walter Mantel. High-street, Alton, Hants.
Parker, Rev. William. Saham, Norfolk.
1853. ‡Parker, William. Thornton-le-Moor, Lincolnshire.
1865. *Parkes, Samuel Hickling. King's Norton, near Birmingham.
1864 §PARKES, WILLIAM. 23 Abingdon-street, Westminster, S.W.
1859. ‡Parkinson, Robert, Ph.D. West View, Toller-lane, Bradford, Yorkshire.
1862. *Parnell, John, M.A. Hadham House, Upper Clapton, London, E.
Parnell, Richard, M.D., F.R.S.E. Gattonside Villa, Melrose, N.B.
1865. *Parsons, Charles Thomas. 8 Portland-road, Edgbaston, Birmingham.
1855. ‡Paterson, William. 100 Brunswick-street, Glasgow.
1861. ‡Patterson, Andrew. Deaf and Dumb School, Old Trafford, Manchester.
1871. *Patterson, A. H. Craigdarragh, Belfast.
1863. ‡Patterson, H. L. Scott's House, near Newcastle-on-Tyne.
1867. ‡Patterson, James. Kinnettles, Dundee.
1871. ‡*Patterson, John.*
1874. §Patterson, W. H., M.R.I.A. 26 High-street, Belfast.
1863. ‡Pattinson, John. 75 The Side, Newcastle-on-Tyne.
1863. ‡Pattinson, William. Felling, near Newcastle-on-Tyne.
1867. §Pattison, Samuel R., F.G.S. 50 Lombard-street, London, E.C.
1864. ‡Pattison, Dr. T. H. London-street, Edinburgh.
1863. ‡PAUL, BENJAMIN H., Ph.D. 1 Victoria-street, Westminster, S.W.
1863. ‡PAVY, FREDERICK WILLIAM, M.D., F.R.S., Lecturer on Physiology and Comparative Anatomy and Zoology at Guy's Hospital. 35 Grosvenor-street, London, W.
1864. ‡Payne, Edward Turner. 3 Sydney-place, Bath.
1851. ‡Payne, Joseph. 4 Kildare-gardens, Bayswater, London, W.
1866. ‡Payne, Dr. Joseph F. 4 Kildare-gardens, Bayswater, London, W.
1847. ‡PEACH, CHARLES W., Pres. R.P.S. Edin., A.L.S. 30 Haddington-place, Leith-walk, Edinburgh.
1863. §Peacock, Richard Atkinson, C.E., F.G.S. 12 Queen's-road, Jersey.
*Pearsall, Thomas John, F.C.S. Birkbeck Literary and Scientific Institution, Southampton-buildings, Chancery-lane, London, W.C.

Year of Election.

1872. *Pearson, Joseph. 54 Welbeck-terrace, Mansfield-road, Nottingham.
1870. ‡Pearson, Rev. Samuel. 3 Greenheys-road, Prince's Park, Liverpool.
1863. §Pease, H. F. Brinkburn, Darlington.
1863. *Pease, Joseph W., M.P. Hutton Hall, near Guisborough.
1863. ‡Pease, J. W. Newcastle-on-Tyne.
1858. *Pease, Thomas, F.G.S. Cote Bank, Westbury-on-Trym, near Bristol.
Peckitt, Henry. Carlton Husthwaite, Thirsk, Yorkshire.
1855. *Peckover, Alexander, F.L.S., F.R.G.S. Harecroft House, Wisbeach, Cambridgeshire.
*Peckover, Algernon, F.L.S. Sibaldsholme, Wisbeach, Cambridgeshire.
*Peckover, William, F.S.A. Wisbeach, Cambridgeshire.
*Peel, George. Soho Iron Works, Manchester.
1873. §Peel, Thomas. Hampton-place, Horton, Yorkshire.
1861. *Peile, George, jun. Shotley Bridge, Co. Durham.
1861. *Peiser, John. Barnfield House, 491 Oxford-street, Manchester.
1865. ‡Pemberton, Oliver. 18 Temple-row, Birmingham.
1861. *Pender, John, M.P. 18 Arlington-street, London, S.W.
1868. ‡Pendergast, Thomas. Lancefield, Cheltenham.
1856. §PENGELLY, WILLIAM, F.R.S., F.G.S. Lamorna, Torquay.
1845. ‡PERCY, JOHN, M.D., F.R.S., F.G.S., Professor of Metallurgy in the Government School of Mines. Museum of Practical Geology, Jermyn-street, S.W.; and 1 Gloucester-crescent, Hyde Park, London, W.
*Perigal, Frederick. Chatcots, Belsize Park, London, N.W.
1868. *PERKIN, WILLIAM HENRY, F.R.S., F.C.S. The Chestnuts, Sudbury, Harrow.
1861. ‡Perkins, Rev. George. St. James's View, Dickenson-road, Rusholme, near Manchester.
Perkins, Rev. R. B., D.C.L. Wotton-under-Edge, Gloucestershire.
1864. *Perkins, V. R. The Brands, Wotton-under-Edge, Gloucestershire.
1867. ‡*Perkins, William.*
1861. ‡Perring, John Shae. 104 King-street, Manchester.
Perry, The Right Rev. Charles, M.A., Bishop of Melbourne, Australia.
1874. §Perry, John. 5 Falls-road, Belfast.
*Perry, Rev. S. G. F., M.A. Tottington Vicarage, near Bury.
1870. *PERRY, Rev. S. J., F.R.S., F.R.A.S., F.M.S. Stonyhurst College Observatory, Whalley, Blackburn.
1861. *Petrie, John. South-street, Rochdale.
Peyton, Abel. Oakhurst, Edgbaston, Birmingham.
1871. *Peyton, John E. H., F.R.A.S., F.G.S. 108 Marina, St. Leonard's-on-Sea.
1867. ‡PHAYRE, Major-General Sir ARTHUR, K.C.S.I. East India United Service Club, St. James's-square, London, S.W.
1863. *PHENÉ, JOHN SAMUEL, F.S.A., F.G.S., F.R.G.S. 5 Carlton-terrace, Oakley-street, London, S.W.
1870. §Philip, T. D. 51 South Castle-street, Liverpool.
1853. *Philips, Rev. Edward. Hollington, Uttoxeter, Staffordshire.
1853. *Philips, Herbert. 35 Church-street, Manchester.
*Philips, Mark. Welcombe, Stratford-on-Avon.
Philips, Robert N. The Park, Manchester.
1863. ‡Philipson, Dr. 1 Saville-row, Newcastle-on-Tyne.
1859. *PHILLIPS, Major-General Sir B. TRAVELL. United Service Club, Pall Mall, London, S.W.
1862. ‡Phillips, Rev. George, D.D. Queen's College, Cambridge.
1870. ‡PHILLIPS, J. ARTHUR. Cressington Park, Aigburth, Liverpool.

Year of Election.

1868. ‡Phipson, R. M., F.S.A. Surrey-street, Norwich.
1868. ‡Phipson, T. L., Ph.D. 4 The Cedars, Putney, Surrey, S.W.
1864. ‡Pickering, William. Oak View, Clevedon.
1861. ‡Pickstone, William. Radcliff Bridge, near Manchester.
1870. §Picton, J. Allanson, F.S.A. Sandyknowe, Wavertree, Liverpool.
1870. ‡Pigot, Rev. E. V. Malpas, Cheshire.
1871. ‡Pigot, Thomas F. Royal College of Science, Dublin.
*Pike, Ebenezer. Besborough, Cork.
1865. ‡Pike, L. Owen. 25 Carlton-villas, Maida-vale, London, W.
1873. §Pike, W. H. 4 The Grove, Highgate, London, N.
1857. ‡Pilkington, Henry M., M.A., Q.C. 45 Upper Mount-street, Dublin.
1863. *Pim, Captain Bedford C. T., R.N., M.P., F.R.G.S. Leaside, Kingswood-road, Upper Norwood, London, S.E.
Pim, George, M.R.I.A. Brennan's Town, Cabinteely, Dublin.
Pim, Jonathan. Harold's Cross, Dublin.
Pim, William H. Monkstown, Dublin.
1861. ‡*Pincoffs, Simon.*
1868. ‡Pinder, T. R. St. Andrews, Norwich.
1859. ‡Pirrie, William, M.D. 238 Union-street West, Aberdeen.
1866. ‡Pitcairn, David. Dudhope House, Dundee.
1864. ‡Pitt, R. 5 Widcomb-terrace, Bath.
1869. §Plant, James, F.G.S. 40 West-terrace, West-street, Leicester.
1865. ‡Plant, Thomas L. Camp-hill, and 33 Union-street, Birmingham.
1867. ‡Playfair, Lieut.-Colonel, H.M. Consul, Algeria.
1842. Playfair, The Right Hon. Lyon, C.B., Ph.D., LL.D., M.P., F.R.S.L. & E., F.C.S. 4 Queensberry-place, South Kensington, London, S.W.
1857. ‡Plunkett, Thomas. Ballybrophy House, Borris-in-Ossory, Ireland.
1861. *Pochin, Henry Davis, F.C.S. Broughton Old Hall, Manchester.
1846. ‡Pole, William, Mus. Doc., F.R.S. Athenæum Club, Pall Mall, London, S.W.
*Pollexfen, Rev. John Hutton, M.A. East Witton Vicarage, Bedale, Yorkshire.
Pollock, A. 52 Upper Sackville-street, Dublin.
1862. *Polwhele, Thomas Roxburgh, M.A., F.G.S. Polwhele, Truro, Cornwall.
1854. ‡Poole, Braithwaite. Birkenhead.
1868. ‡Pooley, Thomas A., B.Sc. South Side, Clapham Common, London, S.W.
1868. ‡Portal, Wyndham S. Malsanger, Basingstoke.
*Porter, Henry J. Ker, M.R.I.A. New Travellers' Club, 15 George-street, Hanover-square, London, W.
1874. §Porter, Rev. J. Leslie, D.D., LL.D. College Park, Belfast.
1866. §Porter, Robert. Beeston, Nottingham.
Porter, Rev. T. H., D.D. Desertcreat, Co. Armagh.
1863. ‡Potter, D. M. Cramlington, near Newcastle-on-Tyne.
*Potter, Edmund, F.R.S. Camfield-place, Hatfield, Herts.
1842. Potter, Thomas. George-street, Manchester.
1863. ‡Potts, James. 26 Sandhill, Newcastle-on-Tyne.
1857. *Pounden, Captain Lonsdale, F.R.G.S. Junior United Service Club, St. James's-square, London, S.W.; and Brownswood House, Enniscorthy, Co. Wexford.
1873. *Powell, Francis S. Horton Old Hall, Yorkshire; and 1 Cambridge-square, London, W.
1857. ‡Power, Sir James, Bart. Edermine, Enniscorthy, Ireland.
1867. ‡Powrie, James. Reswallie, Forfar.
1855. *Poynter, John E. Clyde Neuck, Uddingstone, Hamilton, Scotland.
1864. ‡*Prangley, Arthur.*

Year of Election.

1869. *Preece, William Henry. Gothic Lodge, Wimbledon Common, London, S.W.
1864. *Prentice, Manning. Violet-hill, Stowmarket, Suffolk.
Prest, The Venerable Archdeacon Edward. The College, Durham.
*Prestwich, Joseph, F.R.S., F.G.S., F.C.S., Professor of Geology in the University of Oxford. 34 Broad-street, Oxford; and Shoreham, near Sevenoaks.
1871. ‡Price, Astley Paston. 47 Lincoln's-Inn-Fields, London, W.C.
1856. *Price, Rev. Bartholomew, M.A., F.R.S., F.R.A.S., Sedleian Professor of Natural Philosophy in the University of Oxford. 11 St. Giles's-street, Oxford.
1872. ‡Price, David S., Ph.D. 26 Great George-street, Westminster, S.W.
Price, J. T. Neath Abbey, Glamorganshire.
1870. §Price, Captain W. E., M.P., F.G.S. Tibberton Court, Gloucester.
1865. *Prichard, Thomas, M.D. Abington Abbey, Northampton.
1865. ‡Prideaux, J. Symes. 209 Piccadilly, London, W.
1864. *Prior, R. C. A., M.D. 48 York-terrace, Regent's Park, London, N.W.
1835. *Pritchard, Andrew, F.R.S.E. 87 St. Paul's-road, Canonbury, London, N.
1846. *Pritchard, Rev. Charles, M.A., F.R.S., F.G.S., F.R.A.S., Professor of Astronomy in the University of Oxford. 8 Keble-terrace, Oxford.
1872. ‡Pritchard, Rev. W. Gee. Brignal Rectory, Barnard Castle, Co. Durham.
1871. ‡Procter, James. Morton House, Clifton, Bristol.
1863. ‡Procter, R. S. Summerhill-terrace, Newcastle-on-Tyne.
Proctor, Thomas. Elmsdale House, Clifton Down, Bristol.
Proctor, William. Elmhurst, Higher Erith-road, Torquay.
1858. §Proctor, William, M.D., F.C.S. 24 Petergate, York.
1863. *Prosser, Thomas. West Boldon, Newcastle-on-Tyne.
1863. ‡Proud, Joseph. South Hetton, Newcastle-on-Tyne.
1865. ‡Prowse, Albert P. Whitchurch Villa, Mannamead, Plymouth.
1872. *Pryor, M. Robert. High Elms, Watford.
1871. *Puckle, Thomas John. Woodcote-grove, Carshalton, Surrey.
1864. ‡Pugh, John. Aberdovey, Shrewsbury.
1873. ‡Pullan, Lawrence. Bridge of Allan, N.B.
1867. ‡Pullar, John. 4 Leonard Bank, Perth.
1867. §Pullar, Robert. 6 Leonard Bank, Perth.
1842. *Pumphrey, Charles. 33 Frederick-road, Edgbaston, Birmingham.
Punnett, Rev. John, M.A., F.C.P.S. St. Earth, Cornwall.
1869. ‡*Purchas, Rev. W. H.*
1852. ‡Purdon, Thomas Henry, M.D. Belfast.
1860. ‡Purdy, Frederick, F.S.S., Principal of the Statistical Department of the Poor Law Board, Whitehall, London. Victoria-road, Kensington, London, W.
1874. §Purser, Frederick, M.A. Rathmines, Dublin.
1866. ‡Purser, Professor John, M.A., M.R.I.A. Queen's College, Belfast.
1860. *Pusey, S. E. B. Bouverie-. 36 Lowndes-street, S.W.; and Pusey House, Faringdon.
1868. §Pye-Smith, P. H., M.D. 31 Finsbury-square, E.C.; and Guy's Hospital, London, S.E.
1861. *Pyne, Joseph John. St. German's Villa, St. Lawrence-road, Notting-hill, W.

1870. ‡Rabbits, W. T. Forest-hill, London, S.E.
1860. ‡Radcliffe, Charles Bland, M.D. 25 Cavendish-square, London, W.
1870. ‡Radcliffe, D. R. Phœnix Safe Works, Windsor, Liverpool.

Year of Election.

*Radford, William, M.D. Sidmount, Sidmouth.
1861. ‡*Rafferty, Thomas.*
1854. ‡Raffles, Thomas Stamford. 13 Abercromby-square, Liverpool.
1870. ‡Raffles, William Winter. Sunnyside, Prince's Park, Liverpool.
1855. ‡Rainey, Harry, M.D. 10 Moore-place, Glasgow.
1864. ‡Rainey, James T. 8 Widcomb-crescent, Bath.
Rake, Joseph. Charlotte-street, Bristol.
1863. ‡RAMSAY, ALEXANDER, jun., F.G.S. 45 Norland-square, Notting-hill, London, W.
1845. ‡RAMSAY, ANDREW CROMBIE, LL.D., F.R.S., F.G.S., Director-General of the Geological Survey of the United Kingdom and of the Museum of Economic Geology, Professor of Geology in the Royal School of Mines. Geological Survey Office, Jermyn-street, London, S.W.
1863. ‡*Ramsay, D. R.*
1867. ‡Ramsay, James, jun. Dundee.
1861. ‡Ramsay, John. Kildalton, Argyleshire.
1867. *Ramsay, W. F., M.D. 15 Somerset-street, Portman-square, London, W.
1873. *Ramsden, William. Bracken Hall, Great Horton, Bradford, Yorkshire.
1835. *Rance, Henry (Solicitor). Cambridge.
1869. *Rance, H. W. Henniker, LL.M. 62 St. Andrew's-street, Cambridge.
1860. ‡Randall, Thomas. Grandepoint House, Oxford.
1865. ‡Randel, J. 50 Vittoria-street, Birmingham.
1855. ‡Randolph, Charles. Pollockshiels, Glasgow.
1860. *Randolph, Rev. Herbert, M.A. Marcham, near Abingdon.
Ranelagh, The Right Hon. Lord. 7 New Burlington-street, Regent-street, London, W.
1868. *Ransom, Edwin, F.R.G.S. Kempstone Mill, Bedford.
1863. §Ransom, William Henry, M.D., F.R.S. The Pavement, Nottingham.
1861. ‡Ransome, Arthur, M.A. Bowdon, Manchester.
Ransome, Thomas. 34 Princess-street, Manchester.
1872. *Ranyard, Arthur Cowper, F.R.A.S. 25 Old-square, Lincoln's-Inn, London, W.C.
Rashleigh, Jonathan. 3 Cumberland-terrace, Regent's Park, London, N.W.
1868. ‡*Rassam, Hormuzed.*
*RATCLIFF, Colonel CHARLES, F.L.S., F.G.S., F.S.A., F.R.G.S. Wyddrington, Edgbaston, Birmingham.
1864. §Rate, Rev. John, M.A. Lapley Vicarage, Penkridge, Staffordshire.
1870. ‡Rathbone, Benson. Exchange-buildings, Liverpool.
1870. ‡Rathbone, Philip H. Greenbank Cottage, Wavertree, Liverpool.
1870. §Rathbone, R. R. 11 Rumford-street, Liverpool.
1863. ‡Rattray, W. St. Clement's Chemical Works, Aberdeen.
1874. §Ravenstein, E. G., F.R.G.S. 10 Lorn-road, Brixton, London, S.W.
Rawdon, William Frederick M.D. Bootham, York.
1870. ‡Rawlins, G. W. The Hollies, Rainhill, Liverpool.
*Rawlins, John. Shrawley Wood House, near Stourport.
1866. *RAWLINSON, Rev. Canon GEORGE, M.A., Camden Professor of Ancient History in the University of Oxford. The Oaks, Precincts, Canterbury.
1855. *RAWLINSON, Major-General Sir HENRY C., K.C.B., LL.D., F.R.S., F.R.G.S. 21 Charles-street, Berkeley-square, London, W.
1868. *RAYLEIGH, The Right Hon. Lord, M.A., F.R.S. 4 Carlton-gardens, Pall Mall, London, S.W.; and Terling Place, Witham, Essex.
1865. ‡Rayner, Henry. West View, Liverpool-road, Chester.
1870. ‡Rayner, Joseph (Town Clerk). Liverpool.

Year of
Election.

1852. ‡Read, Thomas, M.D. Donegal-square West, Belfast.
1865. ‡Read, William. Albion House, Epworth, Bawtry.
*Read, W. H. Rudston, M.A., F.L.S. 12 Blake-street, York.
1870. §Reade, Thomas M., C.E., F.G.S. Blundellsands, Liverpool.
1862. *Readwin, Thomas Allison, M.R.I.A., F.G.S. 37 Osborne-road, Tuebrook, Liverpool.
1852. *REDFERN, Professor PETER, M.D. 4 Lower-crescent, Belfast.
1863. ‡Redmayne, Giles. 20 New Bond-street, London, W.
1863. ‡Redmayne, R. R. 12 Victoria-terrace, Newcastle-on-Tyne.
Redwood, Isaac. Cae Wern, near Neath, South Wales.
1861. *Reé, H. P. Villa Ditton, Torquay.
1861. ‡REED, EDWARD J., Vice-President of the Institute of Naval Architects. Chorlton-street, Manchester.
1869. ‡*Reid, J. Wyatt.*
1874. §Reid, Robert, M.A. Ceylon.
1850. ‡Reid, William, M.D. Cruivie, Cupar, Fife.
1863. §Renals, E. 'Nottingham Express' Office, Nottingham.
1863. ‡Rendel, G. Benwell, Newcastle-on-Tyne.
1867. ‡Renny, W. W. 8 Douglas-terrace, Broughty Ferry, Dundee.
1869. ‡Révy, J. J. 16 Great George-street, Westminster, S.W.
1870. *REYNOLDS, OSBORNE, M.A., Professor of Engineering in Owens College, Manchester. Fallowfield, Manchester.
1858. §Reynolds, Richard, F.C.S. 13 Briggate, Leeds.
1871. ‡REYNOLDS, Professor JAMES EMERSON, M.A., F.C.S. Royal Dublin Society, Kildare-street, Dublin.
Reynolds, William, M.D.
1858. *Rhodes, John. 18 Albion-street, Leeds.
1868. §RICHARDS, Rear-Admiral GEORGE H., C.B., F.R.S., F.R.G.S., Hydrographer to the Admiralty. The Admiralty, Whitehall, London, S.W.
1863. §RICHARDSON, BENJAMIN WARD, M.A., M.D., F.R.S. 12 Hinde-street, Manchester-square, London, W.
1861. §Richardson, Charles. 10 Berkeley-square, Bristol.
1869. *Richardson, Charles. Albert Park, Abingdon, Berks.
1863. *Richardson, Edward, jun. 3 Lovaine-place, Newcastle-on-Tyne.
1868. *Richardson, George. 4 Edward-street, Werneth, Oldham.
1870. ‡Richardson, J. H. 3 Arundel-terrace, Cork.
1868. ‡*Richardson, James C.*
1863. ‡*Richardson, John. W.*
1870. ‡Richardson, Ralph. 16 Coates-crescent, Edinburgh.
Richardson, Thomas. Montpelier-hill, Dublin.
Richardson, William. Micklegate, York.
1861. §Richardson, William. 4 Edward-street, Werneth, Oldham.
1861. ‡Richson, Rev. Canon, M.A. Shakespeare-street, Ardwick, Manchester.
1863. ‡Richter, Otto, Ph.D. 7 India-street, Edinburgh.
1870. ‡Rickards, Dr. 36 Upper Parliament-street, Liverpool.
1868. §Ricketts, Charles, M.D., F.G.S. 22 Argyle-street, Birkenhead.
*RIDDELL, Major-General CHARLES J. BUCHANAN, C.B., R.A., F.R.S Oaklands, Chudleigh, Devon.
1861. *Riddell, Henry B. Whitefield House, Rothbury, Morpeth.
1859. ‡Riddell, Rev. John. Moffat by Beatlock, N.B.
1861. *Rideout, William J. 51 Charles-street, Berkeley-square, London, W.
1872. §Ridge, James. 98 Queen's-road, Brighton.
1862. ‡Ridgway, Henry Akroyd, B.A. Bank Field, Halifax.
1861. ‡Ridley, John. 19 Belsize-park, Hampstead, London, N.W.
1863. *Rigby, Samuel. Bruche Hall, Warrington.
1873. ‡Ripley, Edward. Acacia, Apperley, near Leeds.

Year of Election.

1873. §Ripley, H. W. Acacia, Apperley, near Leeds.
*Ripon, The Marquis of, K.G., D.C.L., F.R.S., F.L.S. 1 Carlton-gardens, London, S.W.
1860. ‡Ritchie, George Robert. 4 Watkyn-terrace, Coldharbour-lane, Camberwell, London, S.E.
1867. ‡Ritchie, John. Fleuchar Craig, Dundee.
1855. ‡Ritchie, Robert, C.E. 14 Hill-street, Edinburgh.
1867. ‡Ritchie, William. Emslea, Dundee.
1869. *Rivington, John. Great Milton, Tetsworth, Oxon.
1854. ‡Robberds, Rev. John, B.A. Battledown Tower, Cheltenham.
1869. *Robbins, J. 104 Portsdown-road, Maida-vale, London, N.W.
Roberton, John. Oxford-road, Manchester.
1859. ‡Roberts, George Christopher. Hull.
1859. ‡Roberts, Henry, F.S.A. Athenæum Club, London, S.W.
1870. *Roberts, Isaac, F.G.S. 26 Rock-park, Rock-ferry, Cheshire.
1857. ‡Roberts, Michael, M.A. Trinity College, Dublin.
1868. §Roberts, W. Chandler, F.G.S., F.C.S. Royal Mint, London, E.
**Roberts, William P.*
1866. ‡Robertson, Alister Stuart, M.D., F.R.G.S. Horwich, Bolton, Lancashire.
1859. ‡Robertson, Dr. Andrew. Indego, Aberdeen.
1867. §Robertson, David. Union Grove, Dundee.
1871. ‡Robertson, George, C.E., F.R.S.E. 47 Albany-street, Edinburgh.
1870. *Robertson, John. Bank, High-street, Manchester.
1866. ‡Robertson, William Tindal, M.D. Nottingham.
1861. ‡Robinson, Enoch. Dukinfield, Ashton-under-Lyne.
1852. ‡Robinson, Rev. George. Tartaragham Glebe, Loughgall, Ireland.
1859. ‡Robinson, Hardy. 156 Union-street, Aberdeen.
*Robinson, H. Oliver. 34 Bishopsgate-street, London, E.C.
1873. §Robinson, Hugh. 3 Donegal-street, Belfast.
1866. ‡*Robinson, John.*
1861. ‡Robinson, John. Atlas Works, Manchester.
1863. ‡Robinson, J. H. Cumberland-row, Newcastle-on-Tyne.
1855. ‡Robinson, M. E. 116 St. Vincent-street, Glasgow.
1860. ‡Robinson, Admiral Robert Spencer. 61 Eaton-place, London, S.W.
Robinson, Rev. Thomas Romney, D.D., F.R.S., F.R.A.S., M.R.I.A., Director of the Armagh Observatory. Armagh.
1863. ‡Robinson, T. W. U. Houghton-le-Spring, Durham.
1870. ‡Robinson, William. 40 Smithdown-road, Liverpool.
1870. *Robson, E. R. 20 Great George-street, Westminster, S.W.
*Robson, Rev. John, M.A., D.D Ajmére Lodge, Cathkin-road, Langside, Glasgow.
1855. ‡Robson, Neil, C.E. 127 St. Vincent-street, Glasgow.
1872. *Robson, William. 3 Palmerston-road, Grange, Edinburgh.
1872. §Rodwell, George F., F.R.A.S., F.C.S. Marlborough College, Wiltshire.
1866. ‡Roe, Thomas. Grove-villas, Sitchurch.
1861. §Rofe, John, F.G.S. 9 Crosbie-terrace, Leamington.
1860. ‡Rogers, James E. Thorold, Professor of Economic Science and Statistics in King's College, London. Beaumont-street, Oxford.
1867. ‡Rogers, James S. Rosemill, by Dundee.
1869. *Rogers, Nathaniel, M.D. 34 Paul-street, Exeter.
1870. ‡Rogers, T. L., M.D. Rainhill, Liverpool.
1859. ‡Rolleston, George, M.A., M.D., F.R.S., F.L.S., Professor of Anatomy and Physiology in the University of Oxford. The Park, Oxford.
1866. ‡Rolph, George Frederick. War Office, Horse Guards, London, S.W.

Year of Election.

1863. ‡Romilly, Edward. 14 Hyde Park-terrace, London, W.
1846. ‡Ronalds, Edmund, Ph.D. Stewartfield, Bonnington, Edinburgh.
1869. ‡Roper, C. H. Magdalen-street, Exeter.
1872. *Roper, Freeman Clark Samuel, F.L.S., F.G.S. Palgrave House, Eastbourne.
1865. *Roper, R. S., F.G.S., F.C.S., A.I.C.E. 14 Clytha-square, Newport, Monmouthshire.
1855. *ROSCOE, HENRY ENFIELD, B.A., Ph.D., F.R.S., F.C.S., Professor of Chemistry in Owens College, Manchester.
1861. ‡ROSE, C. B., F.G.S. 25 King-street, Great Yarmouth, Norfolk.
1863. ‡Roseby, John. Haverholme House, Brigg, Lincolnshire.
1874. §Ross, Alex. Milton, M.A., M.D., F.G.S. Toronto, Canada.
1857. ‡Ross, David, LL.D. Drumbrain Cottage, Newbliss, Ireland.
1872. §Ross, James, M.D. Tenterfield House, Waterfoot, near Manchester.
1859. *Ross, Rev. James Coulman. Baldon Vicarage, Oxford.
1861. *Ross, Thomas. 7 Wigmore-street, Cavendish-square, London, W.
1842. *Ross, William.*
1874. §Ross, Rev. William. Chapelhill Manse, Rothesay, Scotland.
1869. *ROSSE, The Right Hon. The Earl of, D.C.L., F.R.S., F.R.A.S. Birr Castle, Parsonstown, Ireland; and 32 Lowndes-square, London, S.W.
1865. *Rothera, George Bell. 17 Waverley-street, Nottingham.
1861. ‡Routh, Edward J., M.A. St. Peter's College, Cambridge.
1872. *Row, A. V. Nursing Observatory, Daba-gardens, Vizagapatam, India. (Care of Messrs. King & Co., 45 Pall Mall, London, S.W.)
1861. ‡Rowan, David. Elliot-street, Glasgow.
1855. ‡*Rowand, Alexander.*
1865. §Rowe, Rev. John. Load Vicarage, Langport, Somerset.
1855. *ROWNEY, THOMAS H., Ph.D., F.C.S., Professor of Chemistry in Queen's College, Galway. Palmyra-crescent, Galway.
*Rowntree, Joseph. Leeds.
1862. ‡Rowsell, Rev. Evan Edward, M.A. Hambledon Rectory, Godalming.
1861. *Royle, Peter, M.D., L.R.C.P., M.R.C.S. 27 Lever-street, Manchester.
1869. §Rudler, F. W., F.G.S. The Museum, Jermyn-street, London, S.W.
1856. ‡Rumsey, Henry Wyldbore, M.D., F.R.S., F.R.C.S. Priory House, Cheltenham.
1873. ‡Rushforth, Joseph. 43 Ash-grove, Horton-lane, Bradford, Yorkshire.
1847. ‡RUSKIN, JOHN, M.A., F.G.S., Slade Professor of Fine Arts in the University of Oxford. Corpus Christi College, Oxford.
1857. ‡Russell, Rev. C. W., D.D. Maynooth College.
1865. ‡Russell, James, M.D. 91 Newhall-street, Birmingham.
1859. ‡RUSSELL, The Right Hon. JOHN, Earl, K.G., F.R.S., F.R.G.S. 37 Chesham-place, Belgrave-square, London, S.W.
Russell, John.
RUSSELL, JOHN SCOTT, M.A., F.R.S. L. & E. Sydenham; and 5 Westminster Chambers, London, S.W.
1852. *Russell, Norman Scott. 5 Westminster-chambers, London, S.W.
1863. ‡Russell, Robert. Gosforth Colliery, Newcastle-on-Tyne.
1862. §RUSSELL, W. H. L., A.B., F.R.S. 5 The Grove, Highgate, London, N.
1852. *RUSSELL, WILLIAM J., Ph.D., F.R.S., F.C.S., Professor of Chemistry, St. Bartholomew's Medical College. 34 Upper Hamilton-terrace, St. John's Wood, London, N.W.
1865. ‡Rust, Rev. James, M.A. Manse of Slains, Ellon, N.B.
1871. §RUTHERFORD, WILLIAM, M.D., F.R.S.E., Professor of the Institutes of Medicine in the University of Edinburgh.

Year of Election.

Rutson, William. Newby Wiske, Northallerton, Yorkshire.
1871. ‡*Ruttledge, T. E.*
1874. §Rye, E. C., F.Z.S., Librarian R.G.S. Parkfield, Putney, London, S.W.
*Ryland, Arthur. The Linthurst Hill, Broomsgrove, Worcestershire.
1865. ‡Ryland, Thomas. The Redlands, Erdington, Birmingham.
1853. ‡*Rylands, Joseph.*
1861. *RYLANDS, THOMAS GLAZEBROOK, F.L.S., F.G.S. Highfields, Thelwall, near Warrington.

*SABINE, General Sir EDWARD, K.C.B., R.A., LL.D., D.C.L., F.R.S., F.R.A.S., F.L.S., F.R.G.S. 13 Ashley-place, Westminster, S.W.
1865. ‡Sabine, Robert. Auckland House, Willesden-lane, London, N.W.
1871. §Sadler, Samuel Camperdowne. Purton Court, Wiltshire.
1866. *St. Albans, His Grace the Duke of. Bestwood Lodge, Arnold, near Nottingham.
Salkeld, Joseph. Penrith, Cumberland.
1857. ‡SALMON, Rev. GEORGE, D.D., D.C.L., F.R.S., Regius Professor of Divinity in the University of Dublin. Trinity College, Dublin.
1873. *Salomons, Sir David, Bart. Broom-hill, Tunbridge Wells.
1858. *SALT, Sir TITUS, Bart. Crow-Nest, Lightcliffe, near Halifax.
1872. ‡SALVIN, OSBERT, M.A., F.R.S., F.L.S. 32 The Grove, Boltons, London, S.W.
1842. Sambrooke, T. G. 32 Eaton-place, London, S.W.
1861. *Samson, Henry. 6 St. Peter's-square, Manchester.
1867. ‡Samuelson, Edward. Roby, near Liverpool.
1870. ‡SAMUELSON, JAMES. St. Domingo-grove, Everton, Liverpool.
1861. *Sandeman, Archibald, M.A. Tulloch, Perth.
1857. ‡Sanders, Gilbert. The Hill, Monkstown, Co. Dublin.
1872. ‡Sanders, Mrs. 8 Powis-square, Brighton.
*SANDERS, WILLIAM, F.R.S., F.G.S. Hanbury Lodge, The Avenue, Clifton, Bristol.
1871. ‡Sanders, William R., M.D. 11 Walker-street, Edinburgh.
1872. §SANDERSON, J. S. BURDON, M.D., F.R.S. 49 Queen Anne-street, London, W.
Sandes, Thomas, A.B. Sallow Glin, Tarbert, Co. Kerry.
1864. ‡Sandford, William. 9 Springfield-place, Bath.
1854. ‡Sandon, The Right Hon. Lord, M.P. 39 Gloucester-square, London, W.
1873. §Sands, T. C. 24 Spring-gardens, Bradford, Yorkshire.
1865. ‡Sargant, W. L. Edmund-street, Birmingham.
Satterfield, Joshua. Alderley Edge.
1868. ‡Saunders, A., C.E. King's Lynn.
1846. ‡Saunders, Trelawney W. India Office, London, S.W.
1864. ‡Saunders, T. W., Recorder of Bath. 1 Priory-place, Bath.
1860. *Saunders, William. 3 Gladstone-terrace, Brighton.
1871. §Savage, W. D. Ellerslie House, Brighton.
1863. ‡Savory, Valentine. Cleckheaton, near Leeds.
1872. §Sawyer, George David. 55 Buckingham-place, Brighton.
1868. ‡Sawyer, John Robert. Grove-terrace, Thorpe Hamlet, Norwich.
1857. ‡*Scallan, J. Joseph.*
1850. ‡Scarth, Pillans. 2 James's-place, Leith.
1868. §Schacht, G. F. 7 Regent's-place, Clifton, Bristol.
1872. ‡SCHENCK, ROBERT, Ph.D. 398 Manor-terrace, Brixton, London, S.W.
*Schlick, Count Benj. Quai Voltaire, Paris.
1842. Schofield, Joseph. Stubley Hall, Littleborough, Lancashire.

Year of Election.

1874. §Scholefield, Henry. Windsor-crescent, Newcastle-on-Tyne.
*Scholes, T. Seddon. 10 Warwick-place, Leamington.
Schunck, Edward, F.R.S., F.C.S. Oaklands, Kersall Moor, Manchester.
1873. *Schuster, Arthur, Ph.D. Sunnyside, Upper Avenue-road, Regent's Park, London, N.W.
1861. *Schwabe, Edmund Salis. Rhodes House, near Manchester.
1847. ‡Sclater, Philip Lutley, M.A, Ph.D., F.R.S., F.L.S., Sec. Zool. Soc. 11 Hanover-square, London, W.
1867. ‡Scott, Alexander. Clydesdale Bank, Dundee.
1871. ‡Scott, Rev. C. G. 12 Pilrig-street, Edinburgh.
1865. §Scott, Major-General E. W. S., Royal Bengal Artillery. Treledan Hall, Welshpool, Montgomeryshire.
1859. ‡*Scott, Captain Fitzmaurice. Forfar Artillery.*
1872. ‡Scott, George, Curator of the Free Library and Museum, Brighton. 6 Western-cottages, Brighton.
1872. §Scott, Major-General H. Y. D., C.B. Sunnyside, Ealing, W.
1871. ‡Scott, James S. T. Monkrigg, Haddingtonshire.
1857. §Scott, Robert H., M.A., F.R.S., F.G.S., F.M.S., Director of the Meteorological Office. 116 Victoria-street, London, S.W.
1861. §Scott, Rev. Robert Selkirk, D.D. 16 Victoria-crescent, Dowanhill, Glasgow.
1874. §Scott, Rev. Robinson, D.D. Methodist College, Belfast.
1864. ‡Scott, Wentworth Lascelles. Wolverhampton.
1858. ‡Scott, William. Holbeck, near Leeds.
1869. §Scott, William Bower. Chudleigh, Devon.
1864. ‡Scott, William Robson, Ph.D. St. Leonards, Exeter.
1869. ‡Searle, Francis Furlong. 5 Cathedral-yard, Exeter.
1859. ‡Seaton, John Love. Hull.
1870. ‡*Seaton, Joseph, M.D.*
1861. *Seeley, Harry Govier, F.L.S., F.G.S., Professor of Physical Geography, Bedford College, London. 31 Soho-square, London, W.; and St. John's College, Cambridge.
1855. ‡Seligman, H. L. 135 Buchanan-street, Glasgow.
1873. ‡Semple, R. H., M.D. 8 Torrington-square, London, W.C.
1858. *Senior, George, F.S.S. Rose-hill, Dodworth, near Barnsley.
1870. *Sephton, Rev. J. 92 Huskisson-street, Liverpool.
1873. §Sewell, E., M.A., F.R.G.S. Ilkley College, near Leeds.
1868. ‡Sewell, Philip E. Catton, Norwich.
1861. *Seymour, Henry D. 209 Piccadilly, London, W.
Seymour, John. 21 Bootham, York.
1853. ‡Shackles, G. L. 6 Albion-street, Hull.
*Shaen, William. 15 Upper Phillimore-gardens, Kensington, London, W.
1871. *Shand, James. Fullbrooks, Worcester Park, Surrey.
1867. §Shanks, James. Den Iron Works, Arbroath, N.B.
1869. *Shapter, Dr. Lewis. The Barnfield, Exeter.
Sharp, Rev. John, B.A. Horbury, Wakefield.
1861. §Sharp, Samuel, F.G.S., F.S.A. Dallington Hall, near Northampton.
*Sharp, William, M.D., F.R.S., F.G.S. Horton House, Rugby.
Sharp, Rev. William, B.A. Mareham Rectory, near Boston, Lincolnshire.
Sharpey, William, M.D., LL.D., F.R.S., F.R.S.E. 50 Torrington-square, London, W.C.
1858. *Shaw, Bentley. Woodfield House, Huddersfield.
1854. *Shaw, Charles Wright. 3 Windsor-terrace, Douglas, Isle of Man.

Year of Election.

1870. ‡Shaw, Duncan. Cordova, Spain.
1865. ‡Shaw, George. Cannon-street, Birmingham.
1870. ‡Shaw, John. 24 Great George-place, Liverpool.
1845. ‡Shaw, John, M.D., F.L.S., F.G.S. Hop House, Boston, Lincolnshire.
1853. ‡Shaw, Norton, M.D. St. Croix, West Indies.
1839. Shepard, John. 41 Drewton-street, Manningham-road, Bradford, Yorkshire.
1863. ‡Shepherd, A. B. 49 Seymour-street, Portman-square, London, W.
1870. §Shepherd, Joseph. 29 Everton-crescent, Liverpool.
Sheppard, Rev. Henry W., B.A. The Parsonage, Emsworth, Hants.
1869. ‡*Sherard, Rev. S. H.*
1866. ‡Shilton, Samuel Richard Parr. Sneinton House, Nottingham.
1867. §Shinn, William C. Her Majesty's Printing Office, near Fetter-lane, London, E.C.
1870. *Shoolbred, James N., C.E., F.G.S. 12 Delahay-street, Westminster, S.W.
1842. Shuttleworth, John. Wilton Polygon, Cheetham-hill, Manchester.
1866. ‡Sibson, Francis, M.D., F.R.S. 59 Brook-street, London, W.
1861. *Sidebotham, Joseph. 19 George-street, Manchester.
1872. *Sidebottom, Robert. Mersey Bank, Heaton Mersey, Manchester.
1873. §Sidgwick, R. H. The Raikes, Skipton.
1857. ‡Sidney, Frederick John, LL.D., M.R.I.A. 19 Herbert-street, Dublin.
Sidney, M. J. F. Cowpen, Newcastle-upon-Tyne.
1873. *Siemens, Alexander. 12 Queen Anne's-gate, Westminster, S.W.
1856. *Siemens, C. William, D.C.L., F.R.S., F.C.S., M.I.C.E. 12 Queen Anne's-gate, Westminster, S.W.
*Sillar, Zechariah, M.D. Bath House, Laurie Park, Sydenham, London, S.E.
1859. ‡Sim, John. Hardgate, Aberdeen.
1871. ‡Sime, James. Craigmount House, Grange, Edinburgh.
1865. §Simkiss, T. M. Wolverhampton.
1862. ‡Simms, James. 138 Fleet-street, London, E.C.
1852. ‡Simms, William. Albion-place, Belfast.
1874. §Simms, William. The Linen Hall, Belfast.
1847. ‡Simon, John, D.C.L., F.R.S. 40 Kensington-square, London, W.
1866. ‡Simons, George. The Park, Nottingham.
1871. *Simpson, Alexander R., M.D., Professor of Midwifery in the University of Edinburgh. 52 Queen-street, Edinburgh.
1867. ‡Simpson, G. B. Seafield, Broughty Ferry, by Dundee.
1859. ‡Simpson, John. Marykirk, Kincardineshire.
1863. ‡Simpson, J. B., F.G.S. Hedgefield House, Blaydon-on-Tyne.
1857. ‡Simpson, Maxwell, M.D., F.R.S., F.C.S., Professor of Chemistry in Queen's College, Cork.
*Simpson, Rev. Samuel. Greaves House, near Lancaster.
Simpson, Thomas. Blake-street, York.
Simpson, William. Bradmore House, Hammersmith, London, W.
1859. ‡Sinclair, Alexander. 133 George-street, Edinburgh.
1874. §Sinclair, Thomas. Dunedin, Belfast.
1834. ‡Sinclair, Vetch, M.D. 48 Albany-street, Edinburgh.
1870. *Sinclair, W. P. 32 Devonshire-road, Prince's Park, Liverpool.
1864. *Sircar, Baboo Mohendro Lall, M.D. 1344 San Kany, Tollah-street, Calcutta, per Messrs. Harrenden & Co., 3 Chapel-place, Poultry, London, E.C.
1865. §Sissons, William. 92 Park-street, Hull.
1870. §Sladen, Walter Percy, F.G.S. Exley House, near Halifax.

Year of Election.

1873. §Slater, Clayton. Barnoldswick, near Leeds.
1870. §Slater, W. B. 28 Hamilton-square, Birkenhead.
1842. *Slater, William. Park-lane, Higher Broughton, Manchester.
1853. ‡Sleddon, Francis. 2 Kingston-terrace, Hull.
1849. §Sloper, George Edgar. Devizes.
1849. ‡Sloper, Samuel W. Devizes.
1860. §Sloper, S. Elgar. Winterton, near Hythe, Southampton.
1872. ‡Smale, The Hon. Sir John, Chief Justice of Hong Kong.
1867. ‡Small, David. Gray House, Dundee.
1858. ‡Smeeton, G. H. Commercial-street, Leeds.
1867. ‡Smeiton, John G. Panmure Villa, Broughty Ferry, Dundee.
1867. ‡Smeiton, Thomas A. 55 Cowgate, Dundee.
1868. ‡Smith, Augustus. Northwood House, Church-road, Upper Norwood, Surrey, S.E.
1857. ‡Smith, Aquila, M.D., M.R.I.A. 121 Lower Bagot-street, Dublin.
1872. *Smith, Basil Woodd, F.R.A.S. Branch Hill Lodge, Hampstead-heath, London, N.W.
1873. ‡Smith, C. Sidney College, Cambridge.
1865. §SMITH, DAVID, F.R.A.S. 4 Cherry-street, Birmingham.
1865. ‡Smith, Frederick. The Priory, Dudley.
1866. *Smith, F. C., M.P. Bank, Nottingham.
1855. ‡Smith, George. Port Dundas, Glasgow.
1855. ‡Smith, George Cruickshank. 19 St. Vincent-place, Glasgow.
*SMITH, Rev. GEORGE SIDNEY, D.D., M.R.I.A., Professor of Biblical Greek in the University of Dublin. Riverland Glebe, Omagh, Ireland.
*SMITH, HENRY JOHN STEPHEN, M.A., F.R.S., F.C.S., Savilian Professor of Geometry in the University of Oxford, and Keeper of the University Museum. The Museum, Oxford.
1860. *Smith, Heywood, M.A., M.D. 2 Portugal-street, Grosvenor-square, London, W.
1865. ‡*Smith, Isaac.*
1870. ‡Smith, James. 146 Bedford-street South, Liverpool.
1873. ‡*Smith, James.*
1871. *Smith, John Alexander, M.D., F.R.S.E. 10 Palmerston-place, Edinburgh.
1874. §Smith, John Haigh. Beech Hill, Halifax, Yorkshire.
1867. *Smith, John P., C.E. 67 Renfield-street, Glasgow.
Smith, John Peter George.
1852. **Smith, Rev. Joseph Denham.*
*Smith, Philip, B.A. 26 South-hill-park, Hampstead, London, N.W.
1860. *Smith, Protheroe, M.D. 42 Park-street, Grosvenor-square, London, W.
1837. Smith, Richard Bryan. Villa Nova, Shrewsbury.
1847. §SMITH, ROBERT ANGUS, Ph.D., F.R.S., F.C.S. 22 Devonshire-street, Manchester.
*Smith, Robert Mackay. 4 Bellevue-crescent, Edinburgh.
1870. ‡Smith, Samuel. Bank of Liverpool, Liverpool.
1866. §Smith, Samuel. 33 Compton-street, Goswell-road, London, E.C.
1873. ‡Smith, Swire. Lowfield, Keighley, Yorkshire.
1867. ‡Smith, Thomas (Sheriff). Dundee.
1867. ‡Smith, Thomas. Pole Park Works, Dundee.
1859. ‡Smith, Thomas James, F.G.S., F.C.S. Hessle, near Hull.
1852. ‡Smith, William. Eglinton Engine Works, Glasgow.
1857. §SMITH, WILLIAM, C.E., F.G.S., F.R.G.S. 18 Salisbury-street, Adelphi, London, W.C.

Year of Election.

1871. ‡Smith, Professor J. William Robertson. Free Church College, Aberdeen.
1874. §Smoothy, Frederick. Bocking, Essex.
1850. *SMYTH, CHARLES PIAZZI, F.R.S.E., F.R.A.S., Astronomer Royal for Scotland, Professor of Astronomy in the University of Edinburgh. 15 Royal-terrace, Edinburgh.
1870. ‡Smyth, Colonel H. A., R.A. Barrackpore, near Calcutta.
1874. §Smyth, Henry, C.E. Downpatrick, Ireland.
1870. ‡Smyth, H. L. Crabwall Hall, Cheshire.
1857. *SMYTH, JOHN, jun., M.A., M.I.C.E.I., F.M.S. Milltown, Banbridge, Ireland.
1868. ‡Smyth, Rev. J. D. Hurst. 13 Upper St. Giles's-street, Norwich.
1864. ‡SMYTH, WARINGTON W., M.A., F.R.S., F.G.S., F.R.G.S., Lecturer on Mining and Mineralogy at the Royal School of Mines, and Inspector of the Mineral Property of the Crown. 92 Inverness-terrace, Bayswater, London, W.
1854. ‡Smythe, Major-General W. J., R.A., F.R.S. Athenæum Club, Pall Mall, London, S.W.
Soden, John. Athenæum Club, Pall Mall, London, S.W.
*SOLLY, EDWARD, F.R.S., F.L.S., F.G.S., F.S.A. Park House, Sutton, Surrey.
*SOPWITH, THOMAS, M.A., F.R.S., F.G.S., F.R.G.S. 103 Victoria-street, Westminster, S.W.
Sorbey, Alfred. The Rookery, Ashford, Bakewell.
1859. *SORBY, H. CLIFTON, F.R.S., F.G.S. Broomfield, Sheffield.
1865. *Southall, John Tertius. Leominster.
1859. ‡Southall, Norman. 44 Cannon-street West, London, E.C.
1856. ‡Southwood, Rev. T. A. Cheltenham College.
1863. ‡Sowerby, John. Shipcote House, Gateshead, Durham.
1863. *Spark, H. King. Skersgill Park, Penrith.
1859. ‡Spence, Rev. James, D.D. 6 Clapton-square, London, N.E.
*Spence, Joseph. 60 Holgate Hill, York.
1869. *Spence, J. Berger. Erlington House, Manchester.
1854. §Spence, Peter. Pendleton Alum Works, Newton Heath; and Smedley Hall, near Manchester.
1861. ‡Spencer, John Frederick. 28 Great George-street, London, S.W.
1861. *Spencer, Joseph. Bute House, Old Trafford, Manchester.
1863. *Spencer, Thomas. The Grove, Ryton, Blaydon-on-Tyne, Co. Durham.
1875. §Spencer, W. H. Richmond-hill, Clifton, Bristol.
1855. ‡Spens, William. 78 St. Vincent-street, Glasgow.
1871. ‡Spicer, George. Broomfield, Halifax.
1864. *Spicer, Henry, jun., B.A., F.L.S., F.G.S. 14 Aberdeen Park, Highbury, London, N.
1864. §Spicer, William R. 19 New Bridge-street, Blackfriars, London, E.C.
1847. *Spiers, Richard James, F.S.A. Huntercombe, Oxford.
1868. *Spiller, Edmund Pim. 3 Furnival's Inn, London, E.C.
1864. *SPILLER, JOHN, F.C.S. 35 Grosvenor-road, Highbury-new-park, London, N.
1846. *SPOTTISWOODE, WILLIAM, M.A., LL.D., F.R.S., F.R.A.S., F.R.G.S. 50 Grosvenor-place, London, S.W.
1864. *Spottiswoode, W. Hugh. 50 Grosvenor-place, London, S.W.
1854. *SPRAGUE, THOMAS BOND. 26 Buckingham-terrace, Edinburgh.
1853. ‡Spratt, Joseph James. West-parade, Hull.
Square, Joseph Elliot, F.G.S. 24 Portland-place, Plymouth.
*Squire, Lovell. The Observatory, Falmouth.

Year of
Election.

1858. *STAINTON, HENRY T., F.R.S., F.L.S., F.G.S. Mountsfield, Lewisham, S.E.
1851. *Stainton, James Joseph, F.L.S. Horsell, near Ripley, Surrey.
1865. §STANFORD, EDWARD C. C. Edinbarnet, Dumbartonshire, N.B.
1837. Staniforth, Rev. Thos. Storrs, Windermere.
STANLEY, The Very Rev. ARTHUR PENRHYN, D.D., F.R.S., Dean of Westminster. The Deanery, Westminster, London, S.W.
Stapleton, H. M. 1 Mountjoy-place, Dublin.
1866. ‡Starey, Thomas R. Daybrook House, Nottingham.
Staveley, T. K. Ripon, Yorkshire.
1873. *Stead, Charles. The Knoll, Baildon, near Leeds.
1857. ‡Steale, William Edward, M.D. 15 Hatch-street, Dublin.
1870. ‡Stearn, C. H. 3 Elden-terrace, Rock Ferry, Liverpool.
1863. §Steele, Rev. Dr. 2 Bathwick-terrace, Bath.
1873. §Steinthal, G. A. 15 Hallfield-road, Bradford, Yorkshire.
1861. ‡Steinthal, H. M. Hollywood, Fallowfield, near Manchester.
STENHOUSE, JOHN, LL.D., F.R.S., F.C.S. 17 Rodney-street, Pentonville, London, N.
1872. ‡Stennett, Mrs. Eliza. 2 Clarendon-terrace, Brighton.
1861. *Stern, S. J. Littlegrove, East Barnet, Herts.
1863. §Sterriker, John. Driffield.
1872. §Sterry, William. Union Club, Pall Mall, London, S.W.
1870. *Stevens, Miss Anna Maria. Belmont, Devizes-road, Salisbury.
1861. *Stevens, Henry, F.S.A., F.R.G.S. 4 Trafalgar-square, London, W.C.
1863. *Stevenson, Archibald. 2 Wellington-crescent, South Shields.
1850. ‡*Stevenson, David.*
1868. ‡Stevenson, Henry, F.L.S. Newmarket-road, Norwich.
1863. *STEVENSON, JAMES C., M.P. Westoe, South Shields.
1855. ‡STEWART, BALFOUR, M.A., LL.D., F.R.S., Professor of Natural Philosophy in Owens College, Manchester.
1864. ‡STEWART, CHARLES, F.L.S. 19 Princess-square, Plymouth.
1856. *Stewart, Henry Hutchinson, M.D., M.R.I.A. 75 Eccles-street, Dublin.
1847. ‡Stewart, Robert, M.D. The Asylum, Belfast.
1867. ‡Stirling, Dr. D. Perth.
1868. ‡Stirling, Edward. 34 Queen's-gardens, Hyde Park, London, W.
1867. *Stirrup, Mark. 14 Atkinson-street, Deangate, Manchester.
1865. *Stock, Joseph S. Showell Green, Spark Hill, near Birmingham.
Stoddart, George.
1864. §STODDART, WILLIAM WALTER, F.G.S., F.C.S. 7 King-square, Bristol.
1854. ‡Stoess, Le Chevalier, Ch. de W. (Bavarian Consul). Liverpool.
*STOKES, GEORGE GABRIEL, M.A., D.C.L., LL.D., Sec. R.S., Lucasian Professor of Mathematics in the University of Cambrdge. Lensfield Cottage, Lensfield-road, Cambridge.
1862. ‡STONE, EDWARD JAMES, M.A., F.R.S., F.R.A.S., Astronomer Royal at the Cape of Good Hope. Cape Town.
1874. §Stone, J. F. M., F.L.S. St. Peter's College, Cambridge.
1859. ‡Stone, Dr. William H. 13 Vigo-street, London, W.
1857. ‡STONEY, BINDON B., M.R.I.A., Engineer of the Port of Dublin. 42 Wellington-road, Dublin.
1861. *STONEY, GEORGE JOHNSTONE, M.A., F.R.S., M.R.I.A., Secretary to the Queen's University, Ireland. Weston House, Dundrum, Co. Dublin.
1854. ‡Store, George. Prospect House, Fairfield, Liverpool.
1873. ‡Storr, William. The 'Times' Office, Printing-house-square, London, E.C.

Year of Election.

1867. ‡STORRAR, JOHN, M.D. Heathview, Hampstead, London, N.W.
1859. §Story, James. 17 Bryanston-square, London, W.
1874. §Stott, William. Greetland, near Halifax, Yorkshire.
1871. *STRACHEY, Major-General RICHARD, R.E., C.S.I., F.R.S., F.R.G.S., F.L.S., F.G.S. Stowey House, Clapham Common, London, S.W.
1863. ‡Straker, John. Wellington House, Durham.
1868. ‡STRANGE, Lieut.-Colonel A., F.R.S., F.R.A.S., F.R.G.S. India Stores, Belvedere-road, Lambeth, London, S.E.
*Strickland, Charles. Loughglyn House, Castlerea, Ireland.
Strickland, William. French-park, Roscommon, Ireland.
1859. ‡Stronach, William, R.E. Ardmellie, Banff.
1867. ‡Stronner, D. 14 Princess-street, Dundee.
1866. *STRUTT, The Hon. ARTHUR, F.G.S. Milford House, Derby.
1872. *Stuart, Edward A. Sudbury-hill, Harrow.
1864. ‡Style, Sir Charles, Bart. 102 New Sydney-place, Bath.
1873. §Style, George, M.A. Giggleswick School, Yorkshire.
1857. ‡SULLIVAN, WILLIAM K., Ph.D., M.R.I.A. Royal College of Science for Ireland; and 53 Upper Leeson-road, Dublin.
1873. ‡Sutcliffe, J. W. Sprink Bank, Bradford, Yorkshire.
1873. ‡Sutcliffe, Robert. Idle, near Leeds.
1863. ‡Sutherland, Benjamin John. 10 Oxford-street, Newcastle-on-Tyne.
1862. *SUTHERLAND, GEORGE GRANVILLE WILLIAM, Duke of, K.G., F.R.S., F.R.G.S. Stafford House, London, S.W.
1855. ‡*Sutton, Edwin.*
1863. §SUTTON, FRANCIS, F.C.S. Bank Plain, Norwich.
1861. *Swan, Patrick Don S. Kirkcaldy, N.B.
1862. *SWAN, WILLIAM, LL.D., F.R.S.E., Professor of Natural Philosophy in the University of St. Andrews. 2 Hope-street, St. Andrews, N.B.
1862. *Swann, Rev. S. Kirke. Gedling, near Nottingham.
Sweetman, Walter, M.A., M.R.I.A. 4 Mountjoy-square North, Dublin.
1870. *Swinburne, Sir John. Capheaton, Newcastle-on-Tyne.
1863. ‡Swindell, J. S. E. Summerhill, Kingswinford, Dudley.
1873. *Swinglehurst, Henry. Hincaster House, near Milnthorpe.
1863. ‡SWINHOE, ROBERT, F.R.G.S., Her Majesty's Consul at Taiwan. 33 Carlyle-square, S.W.; and Oriental Club, London, W.
1873. §Sykes, Benjamin Clifford, M.D. Cleckheaton.
1847. ‡Sykes, H. P. 47 Albion-street, Hyde Park, London, W.
1862. ‡Sykes, Thomas. Cleckheaton, near Leeds.
1847. ‡Sykes, Captain W. H. F. 47 Albion-street, Hyde Park, London, W.
SYLVESTER, JAMES JOSEPH, M.A., LL.D., F.R.S. 60 Maddox-street, W.; and Athenæum Club, London, S.W.
1870. §SYMES, RICHARD GLASCOTT, A.B., F.G.S., Geological Survey of Ireland. 14 Hume-street, Dublin.
1856. *Symonds, Frederick, F.R.C.S. 35 Beaumont-street, Oxford.
1859. ‡Symonds, Captain Thomas Edward, R.N. 10 Adam-street, Adelphi, London, W.C.
1860. ‡SYMONDS, Rev. W. S., M.A., F.G.S. Pendock Rectory, Worcestershire.
1859. §SYMONS, G. J., Sec. M.S. 62 Camden-square, London, N.W.
1855. *SYMONS, WILLIAM, F.C.S. 26 Joy-street, Barnstaple.
Synge, Francis. Glanmore, Ashford, Co. Wicklow.
1872. ‡Synge, Major-General Millington, R.E., F.S.A., F.R.G.S. United Service Club, Pall Mall, London, S.W.

1865. ‡Tailyour, Colonel Renny, R.E. Newmanswalls, Montrose, N. B.

Year of Election.

1871. ‡Tait, Peter Guthrie, F.R.S.E., Professor of Natural Philosophy in the University of Edinburgh. 17 Drummond-place, Edinburgh.
1867. ‡Tait, P. M., F.R.G.S. Oriental Club, Hanover-square, London, W.
§Talbot, William Hawkshead. Hartwood Hall, Chorley, Lancashire.
Talbot, William Henry Fox, M.A., LL.D., F.R.S., F.L.S. Lacock Abbey, near Chippenham.
1874. §Talmage, C. G. Leyton Observatory, Essex, E.
Taprell, William. 7 Westbourne-crescent, Hyde Park, London, W.
1866. ‡Tarbottom, Marrott Ogle, M.I.C.E., F.G.S. Newstead-grove, Nottingham.
1861. *Tarratt, Henry W. Bushbury Lodge, Leamington.
1856. ‡Tartt, William Macdonald, F.S.S. Sandford-place, Cheltenham.
1857. *Tate, Alexander. 2 Queen's-elms, Belfast.
1863. ‡Tate, John. Alnmouth, near Alnwick, Northumberland.
1870. ‡Tate, Norman A. 7 Nivell-chambers, Fazackerley-street, Liverpool.
1865. ‡*Tate, Thomas.*
1858. *Tatham, George. Springfield Mount, Leeds.
1864. *Tawney, Edward B., F.G.S. 16 Royal York-crescent, Clifton, Bristol.
1871. ‡Tayler, William, F.S.A., F.S.S. 28 Park-street, Grosvenor-square, London, W.
1874. §Taylor, Alexander O'Driscoll. 3 Upper-crescent, Belfast.
1867. ‡Taylor, Rev. Andrew. Dundee.
Taylor, Frederick. Laurel-cottage, Rainhill, near Prescot, Lancashire.
1874. §Taylor, G. P. Students' Chambers, Belfast.
*Taylor, James. Culverlands, near Reading.
*Taylor, John, F.G.S. 6 Queen-street-place, Upper Thames-street, London, E.C.
1861. *Taylor, John, jun. 6 Queen-street-place, Upper Thames-street, London, E.C.
1873. §Taylor, John Ellor, F.L.S., F.G.S. The Mount, Ipswich.
1865. ‡Taylor, Joseph. 99 Constitution-hill, Birmingham.
Taylor, Captain P. Meadows, in the Service of His Highness the Nizam. Harold Cross, Dublin.
*Taylor, Richard, F.G.S. 6 Queen-street-place, Upper Thames-street, London, E.C.
1870. §Taylor, Thomas. Aston Rowant, Tetsworth, Oxon.
*Taylor, William Edward. Millfield House, Enfield, near Accrington.
1858. ‡Teale, Thomas Pridgin, jun. 20 Park-row, Leeds.
1869. ‡Teesdale, C. S. M. Pennsylvannia, Exeter.
1863. ‡Tennant, Henry. Saltwell, Newcastle-on-Tyne.
*Tennant, James, F.G.S., F.R.G.S., Professor of Mineralogy in King's College. 149 Strand, London, W.C.
1857. ‡Tennison, Edward King. Kildare-street Club House, Dublin.
1866. ‡Thackeray, J. L. Arno Vale, Nottingham.
1859. ‡Thain, Rev. Alexander. New Machar, Aberdeen.
1848. ‡Thirlwall, The Right Rev. Connop, D.D., F.G.S. 59 Pulteney-street, Bath.
1871. ‡Thin, James. 7 Rillbank-terrace, Edinburgh.
1871. §Thiselton-Dyer, W. T., M.A., B.Sc., F.L.S. 10 Gloucester-road, Kew, W.
1835. Thom, John. Lark-hill, Chorley, Lancashire.
1870. ‡Thom, Robert Wilson. Lark-hill, Chorley, Lancashire.
1871. §Thomas, Ascanius William Nevill. Chudleigh, Devon.
Thomas, George. Brislington, Bristol.

Year of Election.

1869. ‡Thomas, H. D. Fore-street, Exeter.
1869. §Thomas, J. Henwood, F.R.G.S. Custom House, London, E.C.
*Thompson, Corden, M.D. 84 Norfolk-street, Sheffield.
1863. ‡Thompson, Rev. Francis. St. Giles's, Durham.
1858. *Thompson, Frederick. South-parade, Wakefield.
1859. §Thompson, George, jun. Pidsmedden, Aberdeen.
Thompson, Harry Stephen. Kirby Hall, Great Ouseburn, Yorkshire.
1870. ‡THOMPSON, Sir HENRY. 35 Wimpole-street, London, W.
Thompson, Henry Stafford. Fairfield, near York.
1861. *Thompson, Joseph. Woodlands, Fulshaw, near Manchester.
1864. ‡THOMPSON, Rev. JOSEPH HESSELGRAVE, B.A. Cradley, near Brierley-hill.
Thompson, Leonard. Sheriff-Hutton Park, Yorkshire.
1873. ‡Thompson, M. W. Guiseley, Yorkshire.
1874. §Thompson, Robert. Royal-terrace, Belfast.
1863. ‡Thompson, William. 11 North-terrace, Newcastle-on-Tyne.
1867. ‡Thoms, William. Magdalen-yard-road, Dundee.
1855. ‡THOMSON, ALLEN, M.D., LL.D., F.R.S.L. & E., Professor of Anatomy in the University of Glasgow.
1852. ‡Thomson, Gordon A. Bedeque House, Belfast.
Thomson, Guy. Oxford.
1855. ‡Thomson, James. 82 West Nile-street, Glasgow.
1850. *THOMSON, Professor JAMES, M.A., LL.D., C.E., F.R.S.E. The University, Glasgow.
1868. §THOMSON, JAMES, F.G.S. 276 Eglington-street, Glasgow.
*Thomson, James Gibson. 14 York-place, Edinburgh.
1874. §Thomson, John. St. Helen's, Mount Pottinger, Belfast.
1871. *Thomson, John Millar, F.C.S. King's College, London, W.C.
1863. ‡Thomson, M. 8 Meadow-place, Edinburgh.
1872. §Thomson, Peter. 34 Granville-street, Glasgow.
1871. ‡Thomson, Robert, LL.B. 12 Rutland-square, Edinburgh,
1865. ‡Thomson, R. W., C.E., F.R.S.E. 3 Moray-place, Edinburgh.
1850. ‡THOMSON, THOMAS, M.D., F.R.S., F.L.S. The Cottage, West Farleigh, Maidstone.
1874. §Thomson, William, F.C.S. Royal Institution, Manchester.
1847. *THOMSON, Sir WILLIAM, M.A., LL.D., D.C.L., F.R.S.L. & E., Professor of Natural Philosophy in the University of Glasgow, The College, Glasgow.
1871. §Thomson, William Burnes. 11 St. John's-street, Edinburgh.
1870. ‡*Thomson, W. C., M.D.*
1850. ‡THOMSON, WYVILLE T. C., LL.D., F.R.S., F.G.S., Regius Professor of Natural History in the University of Edinburgh. 20 Palmerston-place, Edinburgh.
1871. ‡Thorburn, Rev. David, M.A. 1 John's-place, Leith.
1852. ‡Thorburn, Rev. William Reid, M.A. Starkies, Bury, Lancashire.
1866. ‡Thornton, James. Edwalton, Nottingham.
*Thornton, Samuel. Oakfield, Moseley, near Birmingham.
1867. ‡Thornton, Thomas. Dundee.
1845. ‡Thorp, Dr. Disney. Suffolk Laun, Cheltenham.
1871. ‡Thorp, Henry. Briarleigh, Sale, near Manchester.
*THORP, The Venerable THOMAS, B.D., F.G.S., Archdeacon of Bristol. Kemerton, near Tewkesbury.
1864. *THORP, WILLIAM, jun., B.Sc., F.C.S. 39 Sandringham-road, Kingsland, E.
1871. §THORPE, T. E., Ph.D., F.R.S.E., F.C.S., Professor of Chemistry in the Yorkshire College of Science, Leeds.

Year of Election.

1868. ‡*Thuillier, Colonel.*
Thurnam, John, M.D. Devizes.
1870. ‡Tichborne, Charles R. S., F.C.S. Apothecaries' Hall of Ireland, Dublin.
1873. *Tiddeman, R. H., M.A., F.G.S. 28 Jermyn-street, London, S.W.
1873. ‡Tilghman, B. C. Philadelphia, United States.
1865. §Timmins, Samuel. Elvetham-road, Edgbaston, Birmingham.
Tinker, Ebenezer. Mealhill, near Huddersfield.
*Tinné, John A., F.R.G.S. Briarly, Aigburth, Liverpool.
1861. *Todhunter, Isaac, M.A., F.R.S., Principal Mathematical Lecturer at St. John's College, Cambridge. Bourne House, Cambridge.
Todhunter, J. 3 College-green, Dublin.
1857. ‡Tombe, Rev. H. J. Ballyfree, Ashford, Co. Wicklow.
1856. ‡Tomes, Robert Fisher. Welford, Stratford-on-Avon.
1864. *Tomlinson, Charles, F.R.S., F.C.S. 3 Ridgmount-terrace, Highgate, London, N.
1863. ‡Tone, John F. Jesmond-villas, Newcastle-on-Tyne.
1865. §Tonks, Edmund, B.C.L. Packwood Grange, Knowle, Warwickshire.
1865. §Tonks, William Henry. The Rookery, Sutton Coldfield.
1873. *Tookey, Charles, F.C.S. Royal School of Mines, Jermyn-street, London, S.W.
1861. *Topham, John, A.I.C.E. High Elms, 265 Mare-street, Hackney, London, E.
1872. *Topley, William, F.G.S. Geological Survey Office, Jermyn-street, London, S.W.
1863. ‡Torrens, Colonel Sir R. R., K.C.M.G. 2 Gloucester-place, Hyde Park, London, W.
1859. ‡Torry, Very Rev. John, Dean of St. Andrews. Coupar Angus, N.B.
Towgood, Edward. St. Neot's, Huntingdonshire.
1873. ‡Townend, W. H. Heaton Hall, Bradford, Yorkshire.
1860. ‡*Townsend, John.*
1857. ‡Townsend, Rev. Richard, M.A., F.R.S., Professor of Natural Philosophy in the University of Dublin. Trinity College, Dublin.
1861. ‡Townsend, William. Attleborough Hall, near Nuneaton.
1854. ‡Towson, John Thomas, F.R.G.S. 47 Upper Parliament-street, Liverpool; and Local Marine Board, Liverpool.
1859. ‡*Trail, Samuel, D.D., LL.D.*
1870. ‡Traill, William A. Geological Survey of Ireland, 14 Hume-street, Dublin.
1868. ‡Traquair, Ramsay H., M.D., Professor of Zoology, Royal College of Science, Dublin.
1865. ‡Travers, William, F.R.C.S. 1 Bath-place, Kensington, London, W.
Tregelles, Nathaniel. Neath Abbey, Glamorganshire.
1868. ‡Trehane, John. Exe View Lawn, Exeter.
1869. ‡Trehane, John, jun. Bedford-circus, Exeter.
1870. ‡Trench, Dr. Municipal Offices, Dale-street, Liverpool.
Trench, F. A. Newlands House, Clondalkin, Ireland.
*Trevelyan, Arthur, J.P. Tyneholme, Pencaitland, N.B.
Trevelyan, Sir Walter Calverley, Bart., M.A., F.R.S.E. F.G.S., F.S.A., F.R.G.S. Athenæum Club, London, S.W.; Wallington, Northumberland; and Nettlecombe, Somerset.
1871. §Tribe, Alfred, F.C.S. 73 Artesian-road, Bayswater, London, W.
1871. ‡Trimen, Roland, F.L.S., F.Z.S. Colonial Secretary's Office, Cape Town, Cape of Good Hope.

Year of Election.

1860. §TRISTRAM, Rev. HENRY BAKER, M.A., LL.D., F.R.S., F.L.S., Canon of Durham. The College, Durham.
1869. ‡Troyte, C. A. W. Huntsham Court, Bampton, Devon.
1864. ‡Truell, Robert. Ballyhenry, Ashford, Co. Wicklow.
1869. ‡Tucker, Charles. Marlands, Exeter.
1847. *Tuckett, Francis Fox. 10 Baldwin-street, Bristol.
‡Tuckett, Frederick. 4 Mortimer-street, Cavendish-square, London, W.
Tuke, James H. Bank, Hitchen.
1871. ‡Tuke, J. Batty, M.D. Cupar, Fifeshire.
1867. ‡Tulloch, The Very Rev. Principal, D.D. St. Andrews, Fifeshire.
1865. §Turberville, H. Pilton, Barnstaple.
1854. ‡TURNBULL, JAMES, M.D. 86 Rodney-street, Liverpool.
1855. §Turnbull, John. 37 West George-street, Glasgow.
1856. ‡Turnbull, Rev. J. C. 8 Bays-hill-villas, Cheltenham.
*TURNBULL, Rev. THOMAS SMITH, M.A., F.R.S., F.G.S., F.R.G.S. Blofield, Norfolk.
1871. §Turnbull, William. 14 Lansdowne-crescent, Edinburgh.
1873. *Turner, George. Horton Grange, Bradford, Yorkshire.
Turner, Thomas, M.D. 31 Curzon-street, Mayfair, London, W.
1863. *TURNER, WILLIAM, M.B., F.R.S.E., Professor of Anatomy in the University of Edinbugh. 6 Eton-terrace, Edinburgh.
1842. Twamley, Charles, F.G.S. 11 Regent's Park-road, London, N.W.
1847. ‡TWISS, Sir TRAVERS, D.C.L., F.R.S., F.R.G.S. 3 Paper-buildings, Temple, London, E.C.
1865. §TYLOR, EDWARD BURNETT, F.R.S. Linden, Wellington, Somerset.
1858. *TYNDALL, JOHN, LL.D., Ph.D., F.R.S., F.G.S., Professor of Natural Philosophy in the Royal Institution. (PRESIDENT.) Royal Institution, Albemarle-street, London, W.
1861. *Tysoe, John. Seedley-road, Pendleton, near Manchester.

1872. ‡Upward, Alfred. 11 Great Queen-street, Westminster, London, S.W.
1855. ‡*Ure, John.*
1859. ‡*Urquhart, Rev. Alexander.*
1859. ‡Urquhart, W. Pollard. Craigston Castle, N.B.; and Castlepollard, Ireland.
1866. §Urquhart, William W. Rosebay, Broughty Ferry, by Dundee.
1873. §Uttley, Hiram. Burnley.

1870. ‡Vale, H. H. 42 Prospect-vale, Fairfield, Liverpool.
*Vance, Rev. Robert. 24 Blackhall-street, Dublin.
1863. ‡Vandoni, le Commandeur Comte de, Chargé d'Affaires de S. M. Tunisienne, Geneva.
1854. ‡Varley, Cromwell F., F.R.S. Fleetwood House, Beckenham, Kent.
1868. §Varley, Frederick H., F.R.A.S. Mildmay Park Works, Mildmay Avenue, Stoke Newington, London, N.
1865. *VARLEY, S. ALFRED. Hatfield, Herts.
1870. ‡Varley, Mrs. S. A. Hatfield, Herts.
1869. ‡Varwell, P. Alphington-street, Exeter.
1863. ‡Vauvert, de Mean A., Vice-Consul for France. Tynemouth.
1849. *Vaux, Frederick. Central Telegraph Office, Adelaide, South Australia.
1873. *Verney, Captain Edmund H., R.N. Rhianva, Bangor, North Wales.
Verney, Sir Harry, Bart. Lower Claydon, Buckinghamshire.
1866. ‡Vernon, Rev. E. H. Harcourt. Cotgrave Rectory, near Nottingham.

Year of Election.

Vernon, George John, Lord. 32 Curzon-street, London, W.; and Sudbury Hall, Derbyshire.
1854. *VERNON, GEORGE V., F.R.A.S. 1 Osborne-place, Old Trafford, Manchester.
1864. *VICARY, WILLIAM, F.G.S. The Priory, Colleton-cresent, Exeter.
1854. *VIGNOLES, Lieut.-Colonel CHARLES B., C.E., F.R.S., M.R.I.A., F.R.A.S., V.P.I.C.E. 15 & 17 Delahay-street, Westminster, S.W.
1868. ‡Vincent, Rev. William. Postwick Rectory, near Norwich.
1856. ‡VIVIAN, EDWARD, B.A. Woodfield, Torquay.
*VIVIAN, H. HUSSEY, M.P., F.G.S. Park Wern, Swansea; and 27 Belgrave-square, London, S.W.
1856. §VOELCKER, J. CH. AUGUSTUS, Ph.D., F.R.S., F.C.S., Professor of Chemistry to the Royal Agricultural Society of England. 39 Argyll-road, Kensington, London, W.
‡Vose, Dr. James. Gambier-terrace, Liverpool.

1860. §Waddingham, John. Guiting Grange, Winchcombe, Gloucestershire.
1859. ‡Waddington, John. New Dock Works, Leeds.
1870. §WAKE, CHARLES STANILAND. 10 Story-street, Hull.
1855. *Waldegrave, The Hon. Granville. 26 Portland-place, London, W.
1873. ‡Wales, James. 4 Mount Royd, Manningham, Bradford, Yorkshire.
1869. *Walford, Cornelius. 86 Belsize-park-gardens, London, N.W.
1849. §WALKER, CHARLES V., F.R.S., F.R.A.S. Fernside Villa, Redhill, near Reigate.
Walker, Sir Edward S. Berry Hill, Mansfield.
Walker, Frederick John. The Priory, Bathwick, Bath.
1866. ‡Walker, H. Westwood, Newport, by Dundee.
1859. ‡*Walker, James.*
1855. ‡Walker, John. 1 Exchange-court, Glasgow.
1842. *Walker, John. Thorncliffe, New Kenilworth-road, Leamington.
1866. *WALKER, J. F., M.A., F.C.P.S., F.C.S., F.G.S., F.L.S. 16 Gillygate, York.
1867. *Walker, Peter G. 2 Airlie-place, Dundee.
1866. ‡Walker, S. D. 38 Hampden-street, Nottingham.
1869. *Walker, Thomas F. W., M.A., F.G.S., F.R.G.S. 3 Circus, Bath.
Walker, William. 47 Northumberland-street, Edinburgh.
1869. ‡Walkey, J. E. C. High-street, Exeter.
1863. ‡WALLACE, ALFRED R., F.R.G.S. The Dell, Grays, Essex.
1859. ‡WALLACE, WILLIAM, Ph.D., F.C.S. Chemical Laboratory, 3 Bath-street, Glasgow.
1857. ‡Waller, Edward. Lisenderry, Aughnacloy, Ireland.
1862. ‡WALLICH, GEORGE CHARLES, M.D., F.L.S. 60 Holland-road, Kensington, London, W.
Wallinger, Rev. William.
1862. ‡WALPOLE, The Right Hon. SPENCER HORATIO, M.A., D.C.L., M.P., F.R.S. Ealing, London, W.
1857. ‡Walsh, Albert Jasper, F.R.C.S.I. 89 Harcourt-street, Dublin.
Walsh, John (Prussian Consul). 1 Sir John's Quay, Dublin.
1863. ‡Walters, Robert. Eldon-square, Newcastle-on-Tyne.
Walton, Thomas Todd. Mortimer House, Clifton, Bristol.
1863. ‡*Wanklyn, James Alfred, F.R.S.E., F.C.S.*
1872. ‡Warburton, Benjamin. Leicester.
1874. §Ward, F. D. 6 University-square, Belfast.
1874. §Ward, John. Royal Ulster Works, Chlorine-place, Botanic-road, Belfast.

Year of Election.

1857. ‡Ward, John S. Prospect-hill, Lisburn, Ireland.
Ward, Rev. Richard, M.A. 12 Eaton-place, London, S.W.
1863. ‡Ward, Robert. Dean-street, Newcastle-on-Tyne.
*Ward, William Sykes, F.C.S. 12 Bank-street, and Denison Hall, Leeds.
1867. ‡Warden, Alexander J. Dundee.
1858. ‡Wardle, Thomas. Leek Brook, Leek, Staffordshire.
1865. ‡Waring, Edward John, M.D., F.L.S. 49 Clifton-gardens, Maida-vale, London, W.
1864. *Warner, Edward. 49 Grosvenor-place, London, S.W.
1872. *Warner, Thomas. 47 Sussex-square, Brighton.
1856. ‡Warner, Thomas H. Lee. Tiberton Court, Hereford.
1865. *Warren, Edward P., L.D.S. 13 Old-square, Birmingham.
1869. ‡*Warren, James L.*
Warwick, William Atkinson. Wyddrington House, Cheltenham.
1856. ‡Washbourne, Buchanan, M.D. Gloucester.
*WATERHOUSE, JOHN, F.R.S., F.G.S., F.R.A.S. Wellhead, Halifax, Yorkshire.
1854. ‡Waterhouse Nicholas. 5 Rake-lane, Liverpool.
1870. ‡Waters, A. T. H., M.D. 29 Hope-street, Liverpool.
1867. ‡Watson, Rev. Archibald, D.D. The Manse, Dundee.
1855. ‡Watson, Ebenezer. 16 Abercromby-place, Glasgow.
1867. ‡Watson, Frederick Edwin. Thickthorn House, Cringleford, Norwich.
*WATSON, HENRY HOUGH, F.C.S. 227 The Folds, Bolton-le-Moors.
WATSON, HEWETT COTTRELL. Thames Ditton, Surrey.
1873. §Watson, Sir James (Lord Provost). Glasgow.
1859. ‡WATSON, JOHN FORBES, M.A., M.D., F.L.S. India Museum, London, S.W.
1863. ‡Watson, Joseph. Bensham-grove, near Gateshead-on-Tyne.
1863. ‡Watson, R. S. 101 Pilgrim-street, Newcastle-on-Tyne.
1867. ‡Watson, Thomas Donald. 41 Cross-street, Finsbury, London, E.C.
1869. ‡Watt, Robert B. E., C. E., F.R.G.S. Ashley-avenue, Belfast.
1861. ‡Watts, Sir James. Abney Hall, Cheadle, near Manchester.
1846. §Watts, John King, F.R.G.S. Market-place, St. Ives, Hunts.
1870. §Watts, William. Oldham Corporation Waterworks, Piethorn, near Rochdale.
1873. *Watts, W. Marshall, D.Sc. Giggleswick Grammar School, near Settle.
1858. ‡Waud, Major E. Manston Hall, near Leeds.
Waud, Rev. S. W., M.A., F.R.A.S., F.C.P.S. Rettenden, near Wickford, Essex.
1862. §WAUGH, Major-General Sir ANDREW SCOTT, R.E., F.R.S., F.R.A.S., F.R.G.S., late Surveyor-General of India, and Superintendent of the Great Trigonometrical Survey. 7 Petersham-terrace, Queen's-gate-gardens, London, W.
1859. ‡Waugh, Edwin. Sager-street, Manchester.
*WAVENEY, Lord, F.R.S. 7 Audley-square, London, W.
*WAY, J. THOMAS, F.C.S. 9 Russell-road, Kensington, London, S.W.
1869. ‡Way, Samuel James. Adelaide, South Australia.
1871. ‡Webb, Richard M. 72 Grand-parade, Brighton.
*WEBB, Rev. THOMAS WILLIAM, M.A., F.R.A.S. Hardwick Vicarage, Hay, South Wales.
1866. *WEBB, WILLIAM FREDERICK, F.G.S., F.R.G.S. Newstead Abbey, near Nottingham.
1859. ‡Webster, John. 42 King-street, Aberdeen.
1864. §Webster, John. Belvoir-terrace, Sneinton, Nottingham.

Year of Election.

1862. ‡Webster, John Henry, M.D. Northampton.
1834. ‡Webster, Richard, F.R.A.S. 6 Queen Victoria-street, London, E.C.
Webster, Thomas, M.A., Q.C., F.R.S. 2 Pump-court, Temple, London, E.C.
1845. ‡Wedgewood, Hensleigh. 17 Cumberland-terrace, Regent's Park, London, N.W.
1854. ‡Weightman, William Henry. Farn Lea, Seaforth, Liverpool.
1865. ‡Welch, Christopher, M.A. University Club, Pall Mall East, London, S.W.
1867. §Weldon, Walter. Abbey Lodge, Merton, Surrey.
1874. §Wells, Thomas. Royal Naval College, Greenwich, S.E.
1850. ‡Wemyss, Alexander Watson, M.D. St. Andrews, N.B.
Wentworth, Frederick W. T. Vernon. Wentworth Castle, near Barnsley, Yorkshire.
1864. *Were, Anthony Berwick. Whitehaven, Cumberland.
1865. ‡*Wesley, William Henry.*
1853. ‡West, Alfred. Holderness-road, Hull.
1870. ‡West, Captain E. W. Bombay.
1853. ‡West, Leonard. Summergangs Cottage, Hull.
1873. ‡West, Samuel H. 6 College-terrace West, London, N.W.
1853. ‡West, Stephen. Hessle Grange, near Hull.
1851. *Western, Sir T. B., Bart. Felix Hall, Kelvedon, Essex.
1870. §Westgarth, William. 3 Brunswick-gardens, Campden-hill, London, W.
1842. Westhead, Edward. Chorlton-on-Medlock, near Manchester.
Westhead, John. Manchester.
1842. *Westhead, Joshua Proctor Brown. Lea Castle, near Kidderminster.
1857. *Westley, William. 24 Regent-street, London, S.W.
1863. ‡Westmacott, Percy. Whickham, Gateshead, Durham.
1860. §Weston, James Woods. Belmont House, Pendleton, Manchester.
1864. §Westropp, W. H. S., M.R.I.A. Lisdoonvarna, Co. Clare.
1860. ‡Westwood, John O., M.A., F.L.S., Professor of Zoology in the University of Oxford. Oxford.
1853. ‡Wheatley, E. B. Cote Wall, Mirfield, Yorkshire.
Wheatstone, Sir Charles, D.C.L., F.R.S., Hon. M.R.I.A., Professor of Experimental Philosophy in King's College, London. 19 Park-crescent, Regent's Park, London, N.W.
1866. ‡Wheatstone, Charles C. 19 Park-crescent, Regent's Park, London, N.W.
1847. ‡Wheeler, Edmund, F.R.A.S. 48 Tollington-road, Holloway, London, N.
1873. ‡Whipple, George Matthew, B.Sc., F.R.A.S. The Observatory, Kew.
1853. ‡Whitaker, Charles. Milton Hill, near Hull.
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1859. *Whitaker, William, B.A., F.G.S. Geological Survey Office, 28 Jermyn-street, London, S.W.
1864. ‡White, Edmund. Victoria Villa, Batheaston, Bath.
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1871. ‡Whitelaw, Alexander. 1 Oakley-terrace, Glasgow.
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1866. §Whitfield, Samuel. Golden Hillock, Small Heath, Birmingham.
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1852. ‡Whitla, Valentine. Beneden, Belfast.
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*Yarborough, George Cook. Camp's Mount, Doncaster.
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Royal Institution.
—— Society.
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